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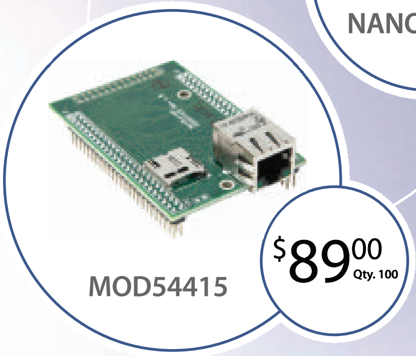
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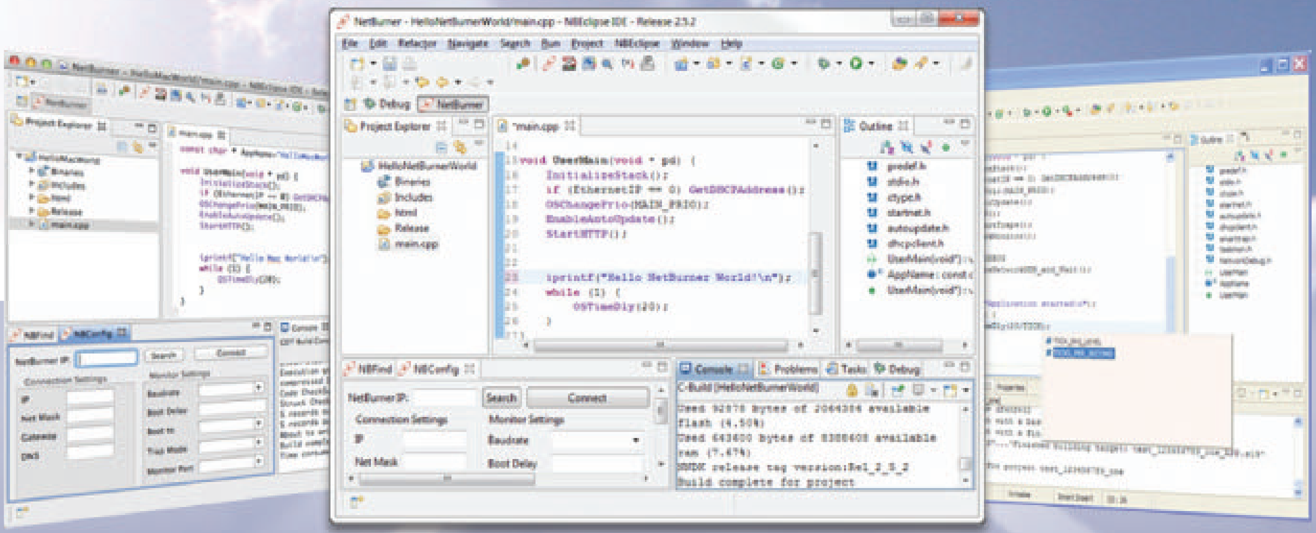
NetBurner - HelloNetBurnerWorld/main.cpp - NBEclipse IDE - Release 2.5.2
File Edit Refactor Navigate Search Run Project NBEclipse Window Help
Debug NetBurner
Project Explorer
HelloNetBurnerWorld
Binaries
Includes
html
Release
main.cpp
*main.cpp
Outline
predef.h
stdio.h
ctype.h
startnet.h
autoupdate.h
dhcpclient.h
NBFind NBConfig
NetBurner IP:
Search
Connect
Connection Settings
Monitor Settings
IP
Baudrate
Net Mask
Boot Delay
Console Problems Tasks Debug
C-Build [HelloNetBurnerWorld]

```
void UserMain(void * pd) {
    InitializeStack();
    if (EthernetIP == 0) GetDHCPAddress();
    OSChangePrio(MAIN_PRIO);
    EnableAutoUpdate();
    StartHTTP();


    iprintf("Hello NetBurner World!\n");
    while (1) {
        OSTimeDly(20);
    }
}
```

```
Used 92978 bytes of 2064384 available
flash (4.50%)
Used 643600 bytes of 8388608 available
ram (7.67%)
NNDK release tag version:Rel_2_5_2
Build complete for project
```

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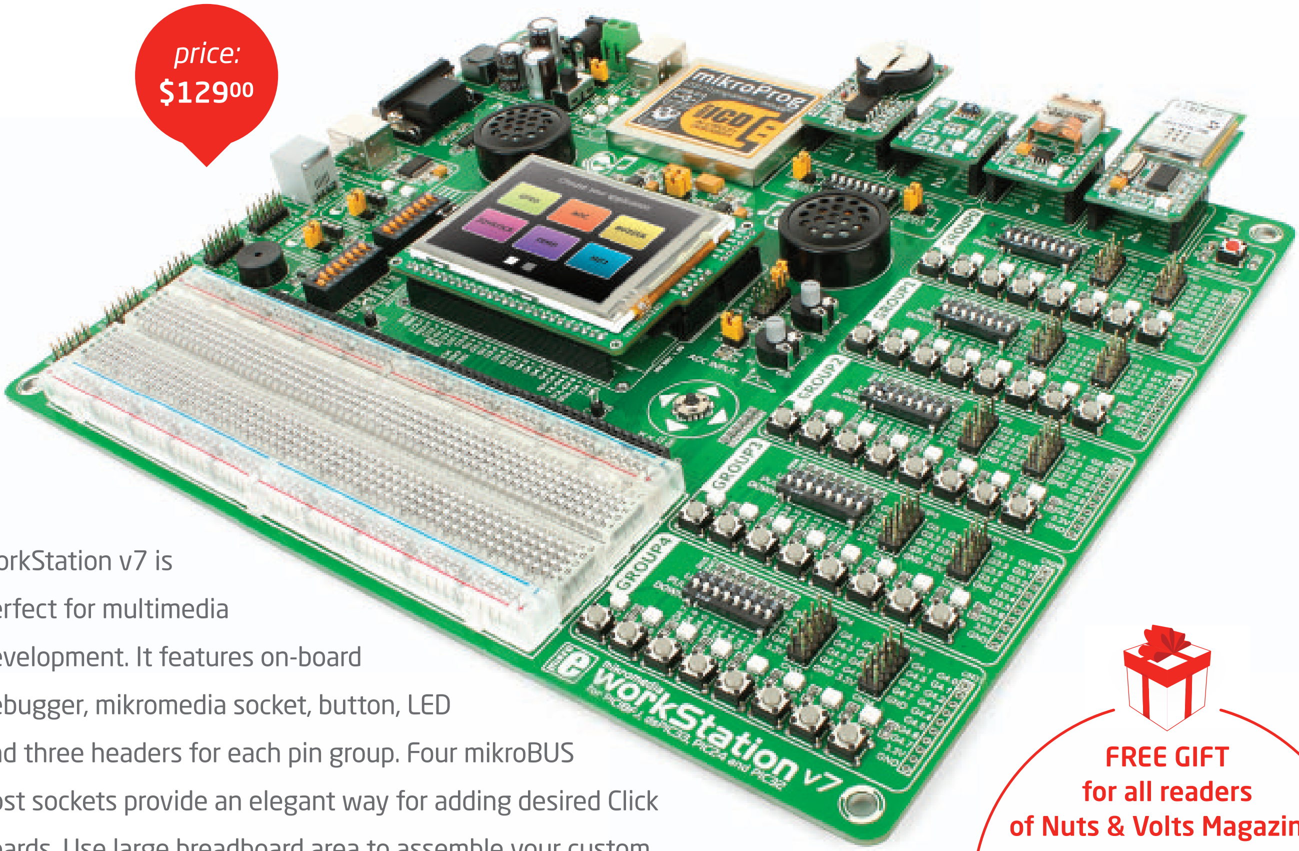

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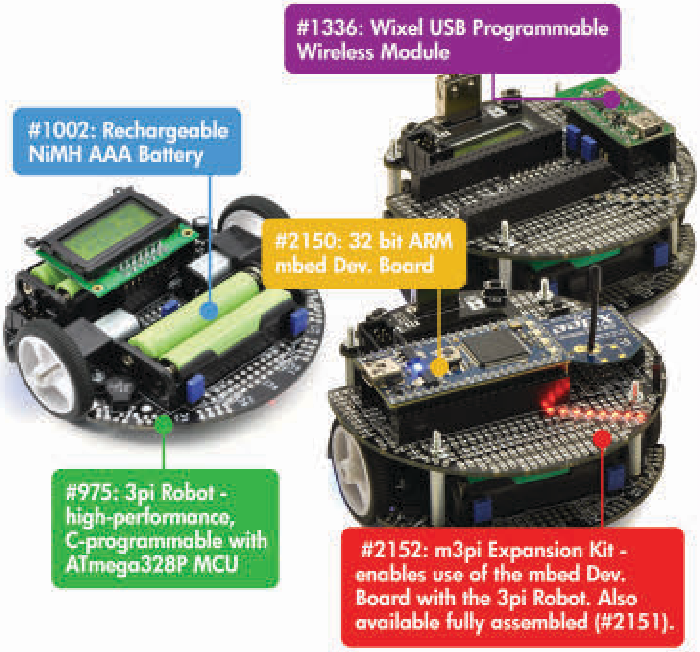
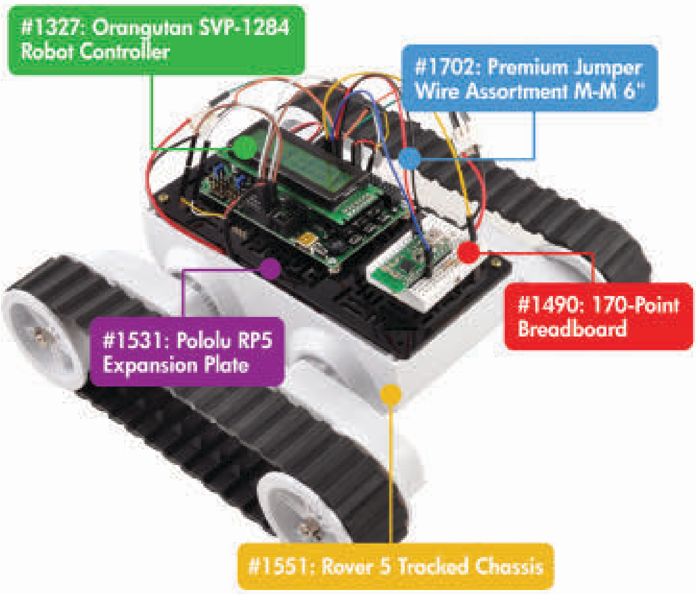
Pololu 3pi and m3pi


#1336: Wixel USB Programmable Wireless Module
#1002: Rechargeable NiMH AAA Battery
#2150: 32 bit ARM mbed Dev. Board
#975: 3pi Robot - high-performance, C-programmable with ATmega328P MCU
#2152: m3pi Expansion Kit - enables use of the mbed Dev. Board with the 3pi Robot. Also available fully assembled (#2151).

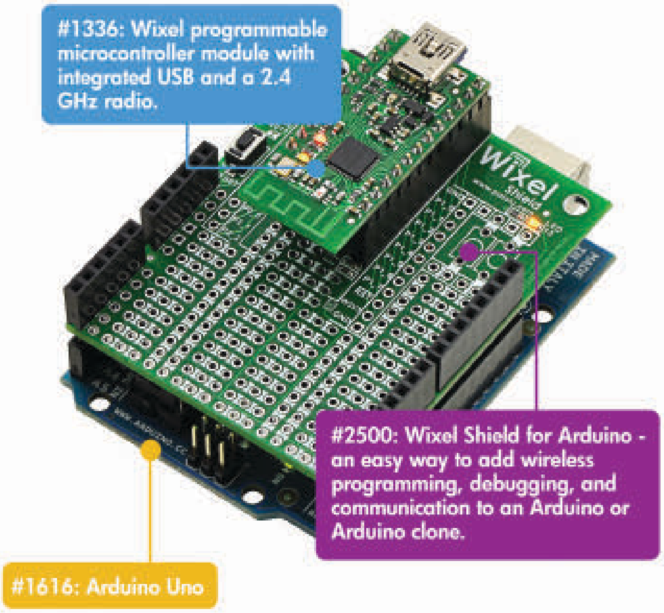
DIY Projects:

Simple Tracked Robot


#1327: Orangutan SVP-1284 Robot Controller
#1702: Premium Jumper Wire Assortment M-M 6"
#1490: 170-Point Breadboard
#1531: Pololu RP5 Expansion Plate
#1551: Rover 5 Tracked Chassis

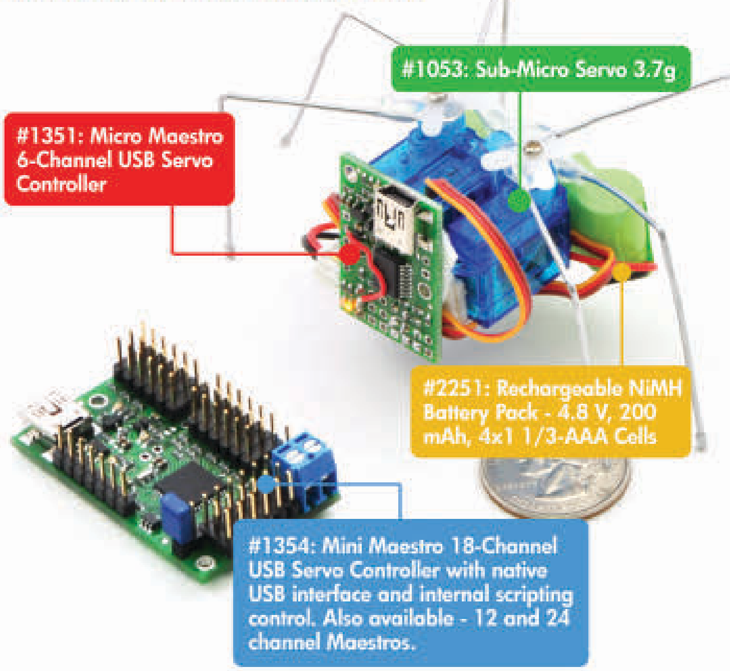
Programmable Controllers:

Wixel and Wixel Shield


#1336: Wixel programmable microcontroller module with integrated USB and a 2.4 GHz radio.
Wixel
#2500: Wixel Shield for Arduino - an easy way to add wireless programming, debugging, and communication to an Arduino or Arduino clone.
#1616: Arduino Uno

Hobby/RC Servo Controllers:

Micro and Mini Maestros


#1053: Sub-Micro Servo 3.7g
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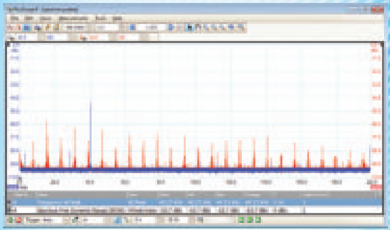
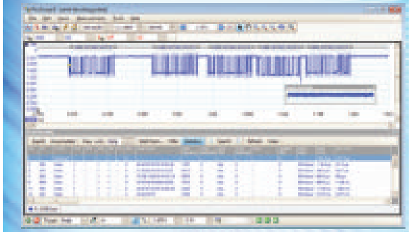
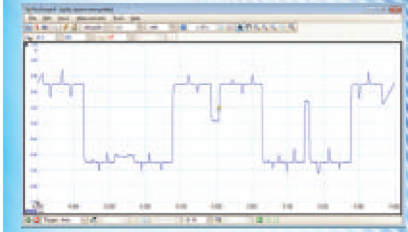
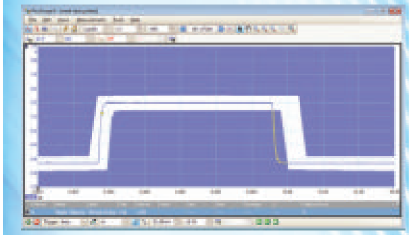
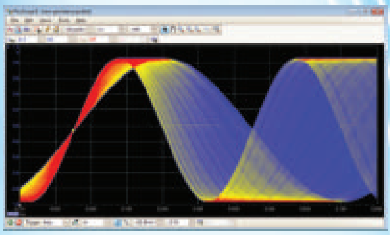

Spectrum analyzer


Serial decoding


Arbitrary waveform
& function generator


Mask limit testing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■ By Gordon McComb

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■ By Walter Noon

Cover photo provided by Matthew Roddy; model is Anais Noon.

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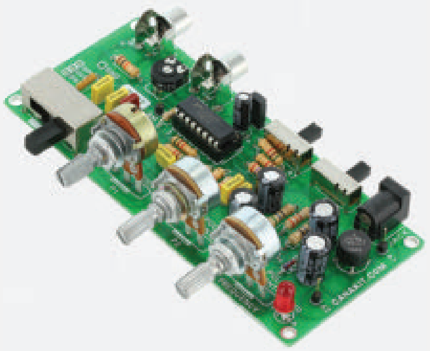

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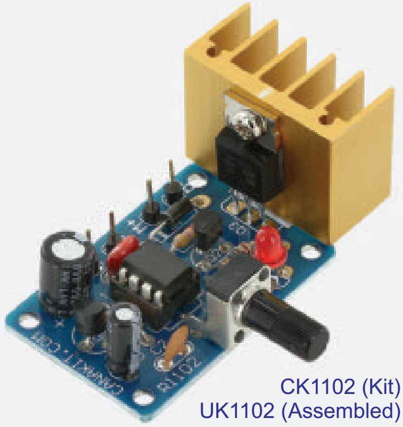
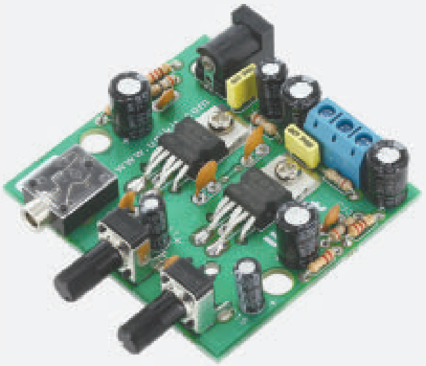


CK1102 (Kit)
UK1102 (Assembled)

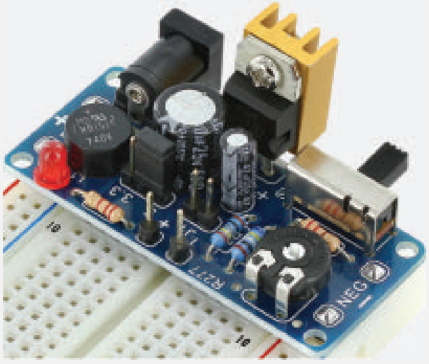
Stereo Audio Amplifier (10W)



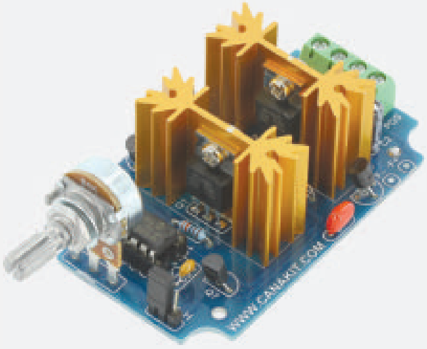
CK560 (Kit)
UK560 (Assembled)

Plug-In Breadboard Power Supply

CK277 (Kit) UK277 (Assembled)

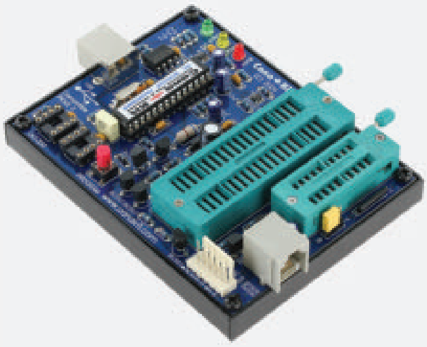


7A Bi-Directional Motor Speed Controller (PWM)



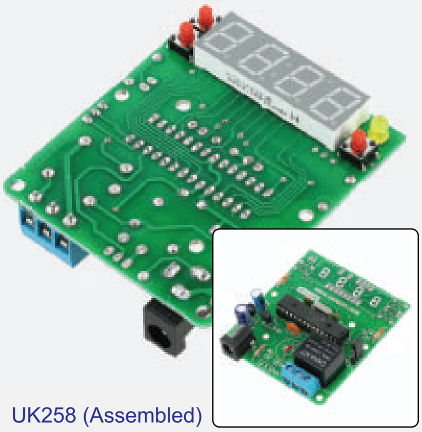
UK1125 (Assembled)

USB PIC Programmer (MPLAB Compatible)



UK1300 (Assembled)

Digital LED Timer (Up/Down)



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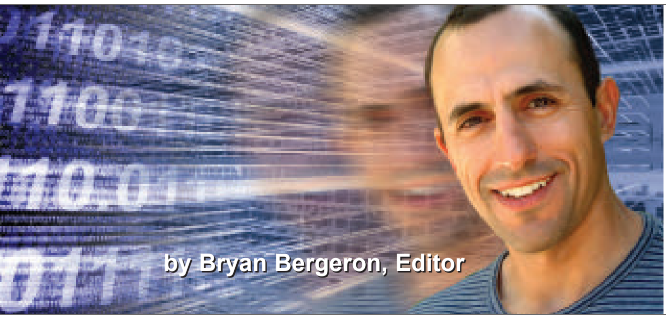

by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

Traveling Light

I'm a fan of tablet computers, the seemingly endless library of apps, and the growing body of hardware add-ons. For example, I've worked with the open source Hijack interface and TechBasic to make a heart rate monitor on my iPad. Also in my add-on library is the suite of virtual instruments from Oscium — a digital oscilloscope, logic analyzer, and spectrum analyzer. These three instruments — each only a bit larger than the standard iPad connector — have (until now) been collecting dust.

The Oscium instruments are first rate — sturdy miniature hardware and robust easy to use software. However, since I have a fully-equipped lab, there's no reason for me to snap on a connector and boot up an iPad app when I have full-scale instruments within arm's reach. I suspect that's the case with many experimenters who are already stocked with test gear.

My virtual instruments no longer collect dust, however. Last week, I was called to make a day trip across country to examine a series of medical devices for a patent infringement case. I had no idea what to expect in terms of equipment on site, and given the tight airline schedule, this was a carry-on flight only. Forget checking a trunk with test equipment, or of putting a standard oscilloscope or spectrum analyzer through the TSA's screening process. So, I grabbed the set of Oscium instruments and put them in the small outer pocket of my backpack. Total weight: about 6 oz and less volume than a miniature USB charger for my phone.

When I arrived on site, I was almost happy to find it ill-equipped. I used the WiPri spectrum analyzer (see the **figure**) to verify Wi-Fi activity and the scope and logic probe, in turn, to look at sensor output and data rates. All in all, lifesavers that paid for themselves in a single trip. So, now I keep the set of instruments in a small camera bag, with the oscilloscope probe and charger in a separate zip-up case — all set for the next flight out.

Although I still use my benchtop gear on a daily basis, I've started using the virtual instruments whenever I'm away from my bench. For example, in tuning up my latest quadcopter, I didn't want anything tall enough to be struck by a spinning blade — that means no workbench. The kitchen table became my test area, and virtual instruments on my thin unobtrusive iPad became my bank of instruments.

I suspect that I'm not alone in my initial excitement over app-based virtual instruments for tablet computers. The question is, when will they make sense for most experimenters? I can see the obvious utility of these hardware and software apps in high school and college physics and electronics courses — forget the antiquated lab gear and bring your own modern digital gear to class. But what of the average experimenter?

I suspect it's a matter of budget and travel habits. With the TSA and airlines forcing smaller and smaller carry-ons and frowning on big boxes loaded with wires and circuit boards, a tablet with add-ons is the way to go.

Another option is to go with several stand-alone, palm-sized instruments. I have one of those cell phone-sized digital oscilloscopes, for example. Unfortunately, I used the $99 scope only twice, in part because it took too long for me to figure out the convoluted menu system, and in part because the case was so poorly constructed that the battery had a tendency to pop out. An

Spectrum
Cursors
Measure
Colors
Settings
Pause
Switch

advantage of a standard interface panel (that is, tablet or smartphone) is that, well, it has a standard interface. Learn one instrument and you learn to use them all. It's the same approach Apple used with the Macintosh which has had a measure of success.

If you have a favorite app and hardware combination for your tablet, please let me and the other readers hear about it. **NV**

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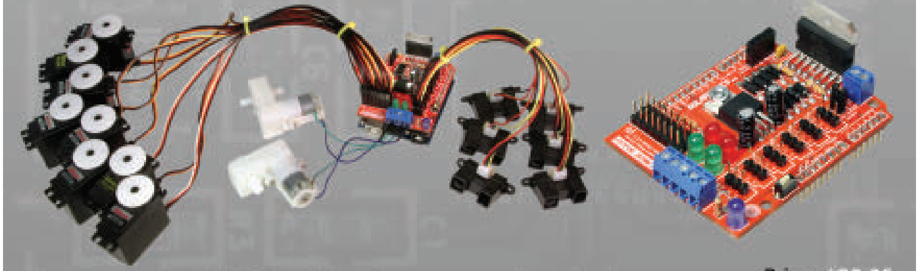

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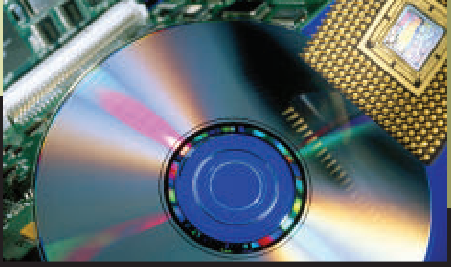


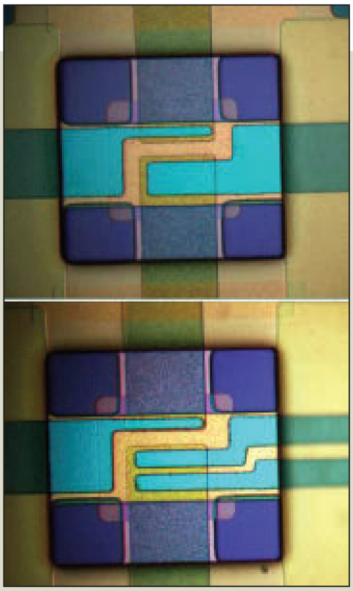
TECH KNOWLEDGEY 2012

EVENTS, ADVANCES, AND NEWS

BY JEFF ECKERT

ADVANCED TECHNOLOGY

MEMS LOGIC GATES IGNORE RADIATION



Tiny (25 x 25 micron) mechanical logic gates perform exclusive “OR" (top) and "AND" (bottom) functions.

Over the years, hardening circuits against electromagnetic pulse (EMP) and ionizing radiation in general has consisted of protecting conventional semiconductors with metal shields or using more exotic materials that inherently resist radiation. However, University of Utah (**www.utah.edu**) engineers recently came up with a way to completely eliminate the semiconductor channels that are disrupted or destroyed by radiation. In something of a technological step backward, they have created a microelectromechanical systems (MEMS) logic gate that consists of mechanical switches instead of semiconductor channels. Instead of using a semiconductive material to carry the current, the new devices use electrical charges to make electrodes touch each other, thus providing a switching action. Each gate takes the place of six to 14 conventional silicon switches to perform "AND," "OR," and "NOT" logical operations.

The concept holds promise not only in military systems but for robots and computer equipment that must function in space and other radioactive environments. A recent example is Japan's Fukushima Daiichi power plant, where robot’s electronics tended to fry after a few hours of exposure. According to Prof. Massood Tabib-Azar, "We have developed a unique technology that keeps on working in the presence of ionizing radiation to provide computation power for critical defense infrastructures. Our devices also can be used in deep space applications in the presence of cosmic ionizing radiation, and can help robotics to control troubled nuclear reactors without degradation."

Because mechanical devices are much slower than silicon and typically require higher voltages, the idea has not been given serious consideration until now. However, Prof. Tabib-Azar's devices operate at only 1.5V and a single device can act as an entire logic gate, thus reducing the number of devices needed by a computer by a factor of 10. More research and funding will be required — as always — but "the next stage would be to build a little computer" using the logic gates and circuits. ▲

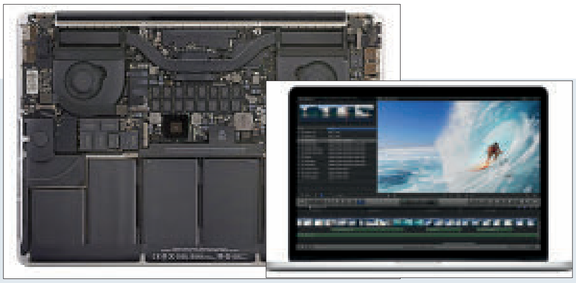
VIRUS GENERATOR DEVELOPED

Finger tapping on virus-laden electrode generates power.

As we know, viruses are nasty little entities that can affect all types of plants, animals, and other organisms. Even though they contain DNA, they are so primitive that they don't even qualify as a life form. In humans, their effects range from such annoyances as the common cold and chickenpox to serious diseases like ebola, AIDS, and severe acute respiratory syndrome (SARS). It now appears that scientists at the US Department of Energy's Lawrence Berkeley National Laboratory (**www.lbl.gov**) have figured out how to harness the little blighters to convert mechanical energy into electricity. In what is billed as the first example of generating electricity by harnessing the piezoelectric properties of a biological material, the researchers have created a generator that employs a postage stamp-size, virus-coated electrode to generate enough current to run a small LCD. Making it even more interesting, the viruses self-assemble themselves into an orderly film that makes the generator work which is a highly prized characteristic in the world of nanotechnology. When pressure is applied to the electrode, the device produces up to 6 nA of current and 400 mV, which is about 1/4 of what you can get out of an AAA cell. With the obligatory further research, it could lead to things like shoe soles and stairsteps that produce essentially free power. In case you're wondering, the device poses no risk to nearby life forms. It uses the M13 bacteriophage which only attacks bacteria. Plus, it replicates itself by the millions within hours, so will always be a plentiful supply. ▲

Discuss this article in the Nuts & Volts forums at http://forum.nutsvolts.com.

COMPUTERS AND NETWORKING



A MINOR DRAWBACK?

As most people have already noticed, Apple introduced a new 15 inch MacBook Pro back in June that incorporates the new Retina display, all Flash storage, and quad-core processors in a design measuring only 0.71 in thick and weighing in at 4.46 lb. The display is the main innovation, providing 220 pixels/inch (denser than an HD TV), a 178° wide viewing angle, 75 percent less reflection, and 29 percent higher contrast than the previous generation. We won't dwell on the particulars which are available at **www.apple.com/macbook-pro**. An interesting consideration here is that one of the design tradeoffs required to achieve ever thinner machines relates to upgradability and repairability. And — according to the folks at iFixit (**www.ifixit.com**) — you get very little of either one. They observed, "The Retina MacBook is the least repairable laptop we've ever taken apart. Unlike the previous model, the display is fused to the glass — meaning replacing the LCD requires buying an expensive display assembly. The RAM is now soldered to the logic board — making future memory upgrades impossible. And the battery is glued to the case, requiring customers to mail their laptop to Apple every so often for a $200 replacement." For many years, my advice to Mac buyers has been to add their own RAM after the purchase to avoid Apple's undesirably high priced upgrades. That doesn't appear to be an option anymore. When the MacBook Pro was introduced in 2009, Steve Jobs observed, "Our Pro customers want accessibility ... to add memory, to add cards, to add drives." This evolution away from accessibility is in many ways regrettable, but as iFixit also noted, "Every time we buy a locked down product containing a non-replaceable battery with a finite cycle count, we're voicing our opinion on how long our things should last ... If we choose the Retina display over the existing MacBook Pro, the next generation of Mac laptops will likely be less repairable still. When that happens, we won't be able to blame Apple. We'll have to blame ourselves." ▲

■ Latest MacBook Pro: slim but inaccessible.

■ WD's top-of-the-line My Net N900 offers dual-band high speed Internet streaming.

NOT JUST FOR HDs ANYMORE

For years, Western Digital has been a familiar provider of external drives, but the company has introduced a line of wireless home networking products designed specifically to provide accelerated streaming of movies, videos, and games. Billed as "the industry's only full line of HD dual-band wireless N routers," WD's My Net® family of dual-band routers employ the company's FasTrack optimization technology to provide smooth streaming for Netflix, Hulu Plus, VUDU, YouTube®, Xbox® LIVE, Skype®, and other services, in up to full 1080p HD quality. Low man on the totem pole is the My Net Switch ($69.99) which is a simple eight-port gigabit switch that expands wired connections via gigabit Ethernet up to 10/100/1000 Mbps. At the other extreme of the six-model family is My Net N900 Central ($349.99) which features speeds up to 900 Mbps (450 + 450 Mbps on the 2.4 and 5 GHz bands combined), plus 1- or 2-TB internal storage for automatic wireless backup. It includes four LAN and one WLAN gigabit Ethernet ports, one USB port, and range amplifier antennas for extended range. Additionally, My Net N900 Central is Universal Plug and Play (UPnP) and Digital Living Network Alliance (DLNA) certified. You can pick one up at your local retailer or shop online at **wdstore.com**. ▲

IN CASE YOU GIVE A FIG ABOUT NEWTON

No, that's not Peter Frampton 30 years ago in the portrait. It's Sir Isaac Newton, about 300 years before the British invasion brought his hair style back into vogue. If you've always been a fan (and who hasn't?), you no longer need to fly to Cambridge to view his papers. The Cambridge University Library holds the largest and most important collection of his scientific works, including the "Portsmouth collection." It was recently announced that the entire lot is now viewable online. This includes the Philosophiae Naturalis Principia Mathematica — published in 1687 — which describes the scientist's now-famous theories regarding the laws of motion and gravity. Better still, the university says it will create online archives of other famous scientist's works in coming months and years. To take a look, just log onto **cudl.lib.cam.ac.uk/collections/newton**. ▲

■ Cambridge University's most famous student, now accessible online.

CIRCUITS AND DEVICES

RADIO SCRAMBLER/DESCRAMBLER

DIGITAL
VOICE
SCRAMBLER
CML
CMX7011

■The CMX7011 provides security for two-way radio signals.

It's not clear how many people actually care who listens in on their wireless communications, but if you're one of them you may be interested in a new digital voice scrambler/descrambler from CML Microcircuits (**www.cmlmicro.com**). The CMX7011 is a half-duplex, digital voice processor designed to implement a digital voice scrambler for use with such conventional radio communication systems as analog mobile radio, wireless door access, and gate entry systems. The device is said to allow simple implementation and configuration within existing designs and can be added to a radio via an accessory port or feature socket. It uses an internal digital scrambling algorithm to achieve high levels of security and high quality speech at the receiving end. It also offers "instant voice capture," featuring push-to-talk (PTT) buffering to eliminate clipping in PMR applications. The CMX7011 operates at 3.0V to 3.6V and comes in a 48-pin LQFP or VQFN package. It's available in the US from Solid State Supplies (**www.sssplc.com**). Price information was not available, so you'll need to make an inquiry. ▲

HANDS-FREE POV VIDEO

■The Aurora model video recording sunglasses from Pivothead.

This month's offering in the category of "neat gadgets you really don't need" is a pair of Pivothead sunglasses which will enable you to look (relatively) cool while shooting (relatively) discreet point of view (POV) videos. They are available in four different styles (Aurora, Durango, Moab, and Recon), none of which looks all that much different from the others. You can shoot both stills and movies; the latter at 1080p/30 fps, 720p/60 fps, or 720p/30 fps. The device offers a Sony 8 MP image sensor, automatic scene adjustment, and 2 GB of built-in SDRAM (expandable to 8 GB). You get a 75° field of view, reportedly with no "fish eye" effect, and the micro USB 2.0 port works with both PC and Mac. A pair is said to cost $349 although — as of this writing — we couldn't locate any dealers. If you are interested in becoming the first dealer in your neighborhood, you can log onto **http://pivothead.com/dealers** to apply. ▲

INDUSTRY AND THE PROFESSION

PANASONIC SINKING?

In 1918, Panasonic Corp. was founded by Konosuke Matsushita as a vendor of lamp sockets, and since then has grown to become one of the 20 largest electronics companies in the world. For years, several of the company's products could be found in the average American's home at any given time, but that doesn't seem to be the case anymore. Panasonic reportedly suffered a January-to-March quarterly loss of $5 billion to bring the fiscal year total to $9.6 billion in the red. This is a stunning reversal from the previous year's $920 million profit. Analysts blame a combination of a strong yen that eroded overseas earnings and stiff competition in the flat-panel display market from Samsung and other Asian companies. The loss is said to be among the largest in Japan's long history of manufacturing. ▲

UPCOMING IC CONFERENCE

If you happen to be interested in developments in ICs that employ such compound semiconductor materials as GaAs, SiGe, and others, you might want to drop in on the 2012 IEEE Compound Semiconductor Integrated Circuit Symposium (CSICS), Oct. 14 through 17, in San Diego, CA. Even if you're not interested, San Diego is a great place to visit in October. The conference (actually located up the road at the Hyatt Regency in La Jolla) will include both exhibits and tutorials, focusing on the science and application of these devices. For details, visit **www.csics.org**. **NV**

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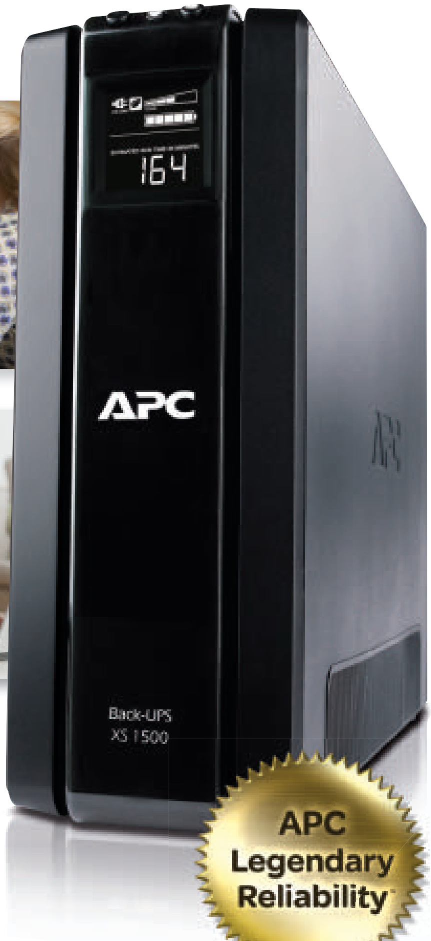

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NEAR SPACE

APPROACHING THE FINAL FRONTIER

■ BY L. PAUL VERHAGE

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

BALLOONSATS AND ATTITUDES TOWARD SCIENCE

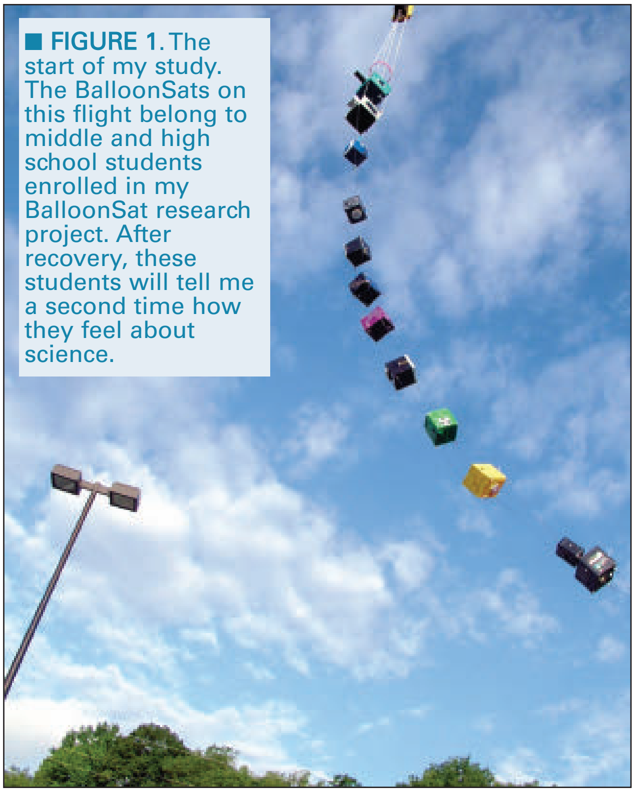
Our nation faces many challenges. One set involves meeting the growing importance of science, technology, engineering, and mathematics (STEM) to the work place. My PhD program at the University of Kansas investigated a possible role for BalloonSats, or model satellites lofted into near space on weather balloons in STEM education. Now that I have completed my dissertation, I will share some of the results with you.

STEM IN TODAY'S WORLD

I began my investigation by becoming acquainted with what other people had to say about STEM in today's world. Three issues made the greatest impression on me: the aging science and engineering workforce; the increasing competition from overseas; and the increasing importance of STEM in everyday life.

According to the National Science Board's Science and Engineering Indicators, more than half of the STEM workforce is 39 and older. Of those holding college degrees, more than one quarter of them are 50 and older. It's no wonder that we can expect retirements in the STEM workforce to increase significantly over the next 20 years.

Currently, more adults are entering into the STEM workforce. Therefore, in time, the number of people entering these fields should balance those retiring. The result will be a STEM workforce that stops growing in size while increasing in average age. We all know cases where older workers can be more productive, but the evidence suggests that young people are more responsible for the most creative research. The need to increase our creative talent becomes obvious when we consider the next concern: increased global competition.



■ **FIGURE 1.** The start of my study. The BalloonSats on this flight belong to middle and high school students enrolled in my BalloonSat research project. After recovery, these students will tell me a second time how they feel about science.

Science and engineering have become global enterprises. Once there was a time that if a student wanted to get a good science or engineering degree, he or she would attend school in the US. Now, overseas schools are granting over one quarter of the STEM-related honors.

Along with increasing STEM education, countries are also developing their STEM-related industries and infrastructure. One result is that more overseas companies can successfully recruit the best and brightest STEM graduates. United States businesses are competing more than ever against these overseas companies. This competition siphons new students away from the STEM talent pool that our country used to draw upon. As a result, it is possible that schools and companies in the US will see a significant reduction in the number of talented individuals coming to them to learn and work.

So far, this article has focused on the STEM workforce and education. Those, however, are not the only issues. Regardless of who is creating the technology — or where — its development continues to advance at a greater pace. The growth of technology increases the need for all people — not just those involved with the STEM workforce — to use high tech tools for entertainment and careers; in fact, in all facets of life. A lack of STEM knowledge today impoverishes a person's access to opportunity.

There are many proposed solutions for this nation's increased need of a STEM knowledgeable population. For example, market forces can change the rewards for entering STEM-related occupations. Currently, many students take degrees in financial services because they offer some of the best rewards to graduates. When industry feels the need to fill more high tech roles, the rewards for getting the training will increase. A second recommendation is to increase every student's STEM education.

STEM EDUCATION

How best can we create an excellent STEM education for students? Robotics often comes to mind, since classrooms have been using them since at least 1970. The best use of classroom robotics is not to necessarily teach programming skills, but to teach other content like mathematics, science, and engineering. Classrooms can even use robotics to teach language arts.

Robots are powerful in education for many reasons. For one, students like robots. As a result, they become more deeply engaged in their education. Students also like spending time with robots. Combine depth of engagement with time engaged and classrooms can keep students enthralled for long periods of time. That's good for education.

Unlike human teachers, robots can give more students immediate feedback. By observing the behavior of their robot, students receive input on how closely they are meeting educational goals. The only problem is that sometimes the robot's feedback can be a mystery or misleading.

Students understand that robots and programmable microcontrollers are real world applications of STEM. Using living examples rather than just theories helps teachers justify educational activities to students. In addition, because of the hands-on nature of robotics, it helps more students learn more content by engaging both their minds and hands.

It's easy to see how classrooms can improve education through the incorporation of robotic projects. Students are more deeply engaged, get more feedback, and learn by using realistic, hands-on applications. If robotics has a weakness, perhaps it is that bots aren't quite as strong in math and science as they are in engineering and technology. So, what if we could create a form of robotics that incorporates more math and science?

BALLOON SATS

Near space entered the classroom some 20 years later than robotics. In the 1990s, near space groups like Windtrax in Indiana, EOSS in Colorado, and Bill Brown in Ohio and Alabama were involving students with the launching and tracking of payloads through the use of amateur radio and weather balloons. These groups also helped some students develop and fly some science experiments. However, in 2001, student access to near space improved astronomically. That's when Chris Kohler of the University of Colorado, Boulder developed the BalloonSat concept.

If you are a regular reader of this column, you know that BalloonSats are self-contained science experiments replicating satellites. BalloonSats let students design experiments to collect data during a mission, without being concerned about the actual launch, chase, and recovery of their experiment. It's very similar to having NASA launch your satellite. You design the satellite to meet NASA's minimum requirements, but you don't concern yourself about the rocket or infrastructure that does the launching.

Because of my 15 years of near space experience, I decided to research the effects of a BalloonSat project in science education. I found that the literature on this subject is not as well developed as it is for robotics. Much of it is descriptive in nature, describing — for example — how schools create and maintain their programs.

So far, I have found one good study about BalloonSats in education. In this study, Taylor University investigated the BalloonSat's effects on science in several arenas. The study found that BalloonSats had the following effects on university students:

1. Students increased their intrinsic motivation to explore and accomplish.
2. Students increased their knowledge of how to problem solve, prototype, evaluate, calibrate, and document.
3. Students increased their ability to self-monitor their learning, to identify and correct errors, and to know when a task was complete.
4. Students increased their near space vocabulary and their technical knowledge of processes (like how to launch a weather balloon).

A BALLOONSAT STUDY

My interest is in pre-college science and engineering education. That's because I feel that innovative programs

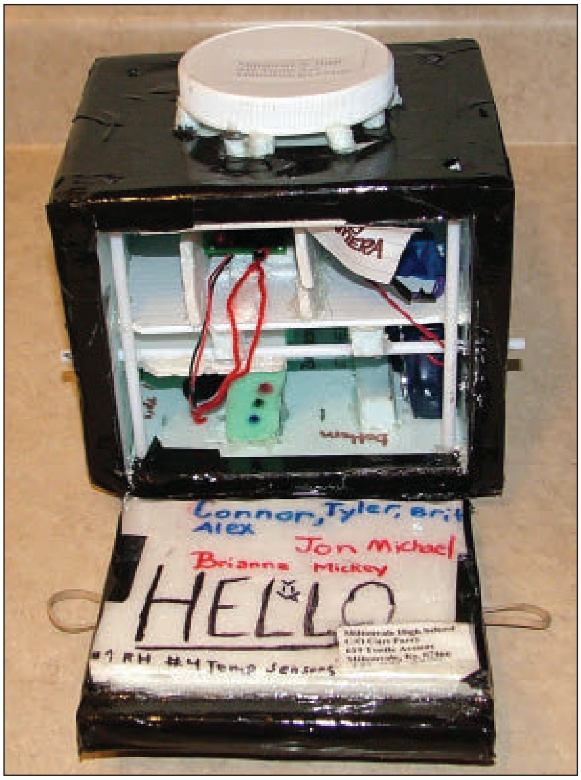


FIGURE 2. This is one of the student BalloonSats. It's a six inch cube with a temperature and relative humidity sensor on top (under the plastic lid) and a digital camera looking out the right side.

must first demonstrate that they can increase younger student's attitudes before they can prove that they are effective at teaching content. I therefore decided to use the Test of Science Related Attitudes (TOSRA) by Dr. Barry Fraser to investigate student attitudes toward science. TOSRA is a survey of 70 statements that investigates seven student attitudes toward science. Students respond to each statement using a five point scale ranging from strongly disagree to strongly agree (in what is known as a Likert scale). The TOSRA survey generates scores for the following seven categories of attitude toward science:

1. The social implications of science.
2. The normality of scientists.
3. Attitude toward scientific inquiry.
4. The adoption of scientific attitudes.
5. The enjoyment of science lessons.
6. Leisure interest in science.
7. Career interest in science.

Before I could begin my investigation, I first needed to design a BalloonSat kit. Each participating classroom received a kit of parts containing the following items:

- BalloonSat mini flight computer kit.
- Sensor kit.
- Modified digital camera.
- Selection of Styrofoam squares, six inches on a side with various thicknesses.
- Correplast square.
- Plastic tubes.
- Plastic lid.
- Visible light blocking filter.
- Thin colored tape.
- Programming cable.

FIGURE 3. What a nice sight! One of my biggest fears was that I would lose BalloonSats and end up not having enough data (students) to complete my study.

The BalloonSat mini kit is a PICAXE-08M2-based programmable datalogger. Students programmed it to record up to 256 analog voltage readings, digitize two analog sensors, and trigger a modified digital camera.

The sensor kit included the following items:

- Three temperature sensors.
- One relative humidity sensor.
- An LED-based photometer with red, green, yellow, and IR LEDs (based on Forrest Mims' design).

By the end of March, I was receiving student BalloonSats in the mail. After they arrived, I tethered the BalloonSats to the APRS tracking modules and the recovery parachute. The next morning, I launched the BalloonSats using either a 1,000 or 1,500 gram weather balloon. The four flights were required to launch all the BalloonSats, and they reached altitudes ranging from 66,400 to 83,800 feet. No BalloonSats were lost, but I did re-fly a few because of the balloon's poor performance.

ANALYZING THE DATA

There were two groups in this study: the experimental group that built a BalloonSat and a control group that did not. Teachers permitted each student to select the group they joined, so there was no random assignment of students to groups (which is the gold standard of research). Looking over the scores of student attitudes, it was obvious that students who chose not to build a BalloonSat had lower average attitudes toward science scores. The two student groups were not identical.

My study was to analyze how the mean (or average) score for each attitude toward science changed after completing the BalloonSat project. To be valid, it would need to compare the change in the mean scores with respect to the spread of scores (called the group variance) for each attitude. Normally, if the difference in the mean scores is large compared to their variances, then the study finds that the difference in the mean is statistically significant. However, because the two groups were not equal at the onset of the study, it was necessary to take this difference into account before comparing the difference in the mean scores. This is called an analysis of covariance or ANCOVA. The covariant for this study was each student's initial attitude scores. You can think of the ANCOVA subtracting out each student's initial attitude scores in order to make both groups look equal before comparing changes in their mean scores. Now I didn't have to do the math, the statistics program SPSS did all the hard work for me. I just had to interpret the results.

THAT'S WHAT ANCOVA SAID

The ANCOVA found no significant difference between the BalloonSat and non-BalloonSat groups in any of the seven attitudes toward science, except for one: Leisure Interest in Science. When students increased their attitude toward leisure interest in science, it means that they have become more interested in things like visiting museums, using telescopes, and joining science clubs. In addition, my study also found that both male and female students responded the same to the BalloonSat project.

The fact that boys and girls responded the same way to the BalloonSats is important. In the past, male and female students expressed different feelings towards science and their science classes. As a result, girls were less likely to study science or receive STEM-related degrees or occupations. One goal of education is to give all students — regardless of gender — equal opportunity to follow their dreams. It's a positive sign that science education specifically and society in general are giving young girls more opportunities to explore science and engineering interests. The difference between the experimental and control group scores in the attitude of Leisure Interest in Science is shown in **Table 1**.

This table is telling us that for Leisure Interest in Science, the mean score for the control group dropped by 0.64 points (out of a maximum of 50) over the spring semester while the mean score for the BalloonSat group increased by 1.02 points over the same time. For readers with a background in statistics, the ANCOVA generated

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Group	Number of Students	Mean Score	Standard Deviation
Pre-Survey BalloonSat	95	31.81	8.09
Pre-Survey Control	88	28.07	8.91
Post-Survey BalloonSat	95	32.83	7.09
Post-Survey Control	88	27.43	8.85

Table 1.

these numbers for Leisure Interest in Science:

$F(1,135) = 3.91,\ p = 0.05$, and partial $\eta^2 = 0.03$

According to the ANCOVA then, there is only a 5% chance that the difference found between the pre-survey and post-survey scores was due to sampling error. In other words, there is only a 5% chance that somehow, students just naturally divided themselves up into groups that would naturally show these results. In addition, only 3% of the difference between the groups was due to the BalloonSat project. Therefore, the effect of the BalloonSat projects as I designed it for this study, appears to be modest at best. However, I see lots of room for improvement.

NEXT UP

I plan further BalloonSat studies. With luck, the next semester long study will begin in January 2013 and a follow on will begin in September 2013 (a yearlong study, in this case). This is where *Nuts & Volts* readers are important. If you are a teacher, or if you know a teacher or principal who would like to be a part of future BalloonSat studies, please have them contact me. My search of the literature informs me that activities like the BalloonSat project are more effective when students have multiple opportunities to participate.

Therefore, I need to find classrooms that can participate for several school years. To find even smaller effects, I will need to increase the number of students, and therefore the number of classrooms involved. The BalloonSat kits will be made available for free, or at a modest cost. I will identify local near space groups to launch the completed student BalloonSats, rather than have all the BalloonSats sent to me for launching.

Another way that *N&V* readers can help out is by mentoring classrooms. Many teachers and students are unfamiliar with electronics and programming. If a school near you is participating in a robotics or BalloonSat activity, please consider lending your expertise to the students. Our nation's STEM future could depend on it.

Onwards and Upwards,
Your near space guide **NV**

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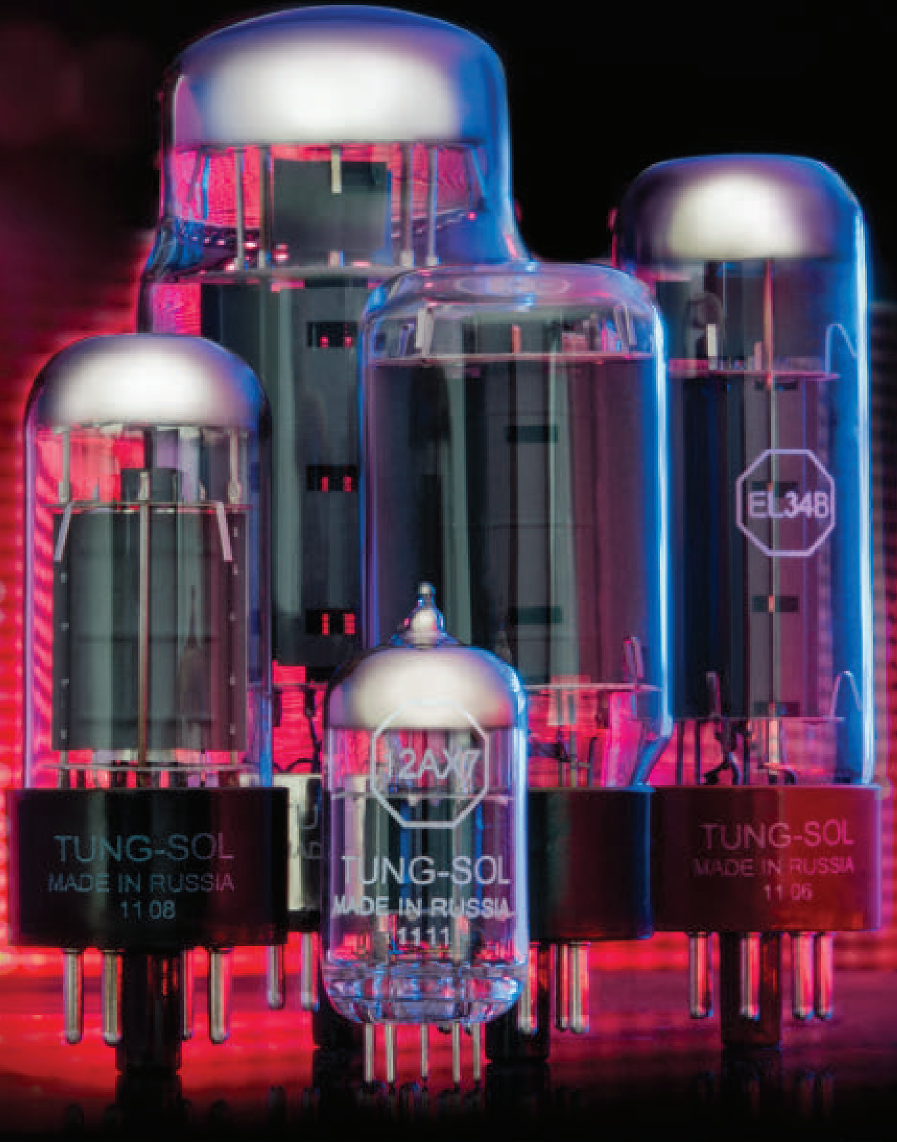

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Driveway System Hack
- ✓ Fan Speed Control
- ✓ Mail Bag

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to:** **Q&A@nutsvolts.com**

DRIVEWAY ALERT SYSTEM HACKS

Q I want to modify a Bunker Hill driveway alert system (it is wireless) model 93068 (from Harbor Freight) to extend the range to a thousand feet and install a relay (or other device) to turn on some flood lights — up to 1,500 watts — for day or night use. These units appear to operate on six and nine volts DC. I would like to extend the time to four to six hours; the existing time is about five seconds.

I also have a motion sensor (Hampton Products International Corp.) from Foothill Ranch, CA. It is a series 7120. I would like to extend the time on it to about 4-6 hours for day or night use. The existing time is about 10 minutes. I want to turn on up to 1,500 watts of power. Both units could be reset manually if need be. As always, cost is the crucial factor.

— Paul Kozlowski

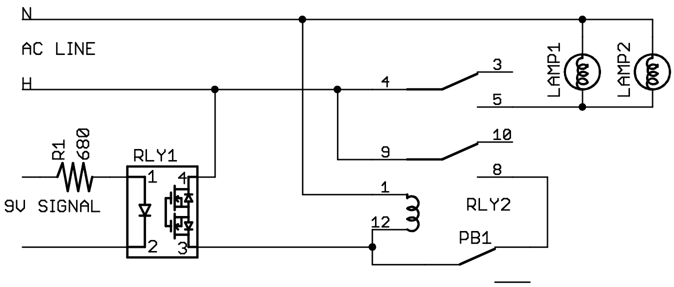
A The transmitter in the driveway alert system operates at 433 MHz; hacking the transmitter to increase the power is not something I would attempt, but you can get a power gain by placing the transmitter at the focal point of a parabolic reflector. The type used for satellite television would work. You could do the same with the receiver but I doubt that it would be necessary.

You can hack the receiver to switch the flood lights. Find the signal that switches the beeper and connect it to a solid-state relay which will operate a mechanical relay in a latching circuit; see **Figure 1**.

A normally closed pushbutton switch will be needed to unlatch (reset) the relay and turn the lights off.

Your motion sensor is thermoplastic which is rated for 150 watt bulbs, and cannot tolerate the heat of 750 watt bulbs. You need to purchase a ceramic or cast aluminum lamp holder. The switch in the motion sensor will be able to operate an AC relay in addition to the 150 watt bulbs. The circuit will be the same as **Figure 1**, minus the solid-state relay.

Be careful with the 120 VAC; be sure the power is off.



PART	MOUSER PART NUMBER
RLY2	769-HE2AN-Q-AC120V
PB1	633-MB2411JW01HA4A-CF
RLY1	558-DPA4111

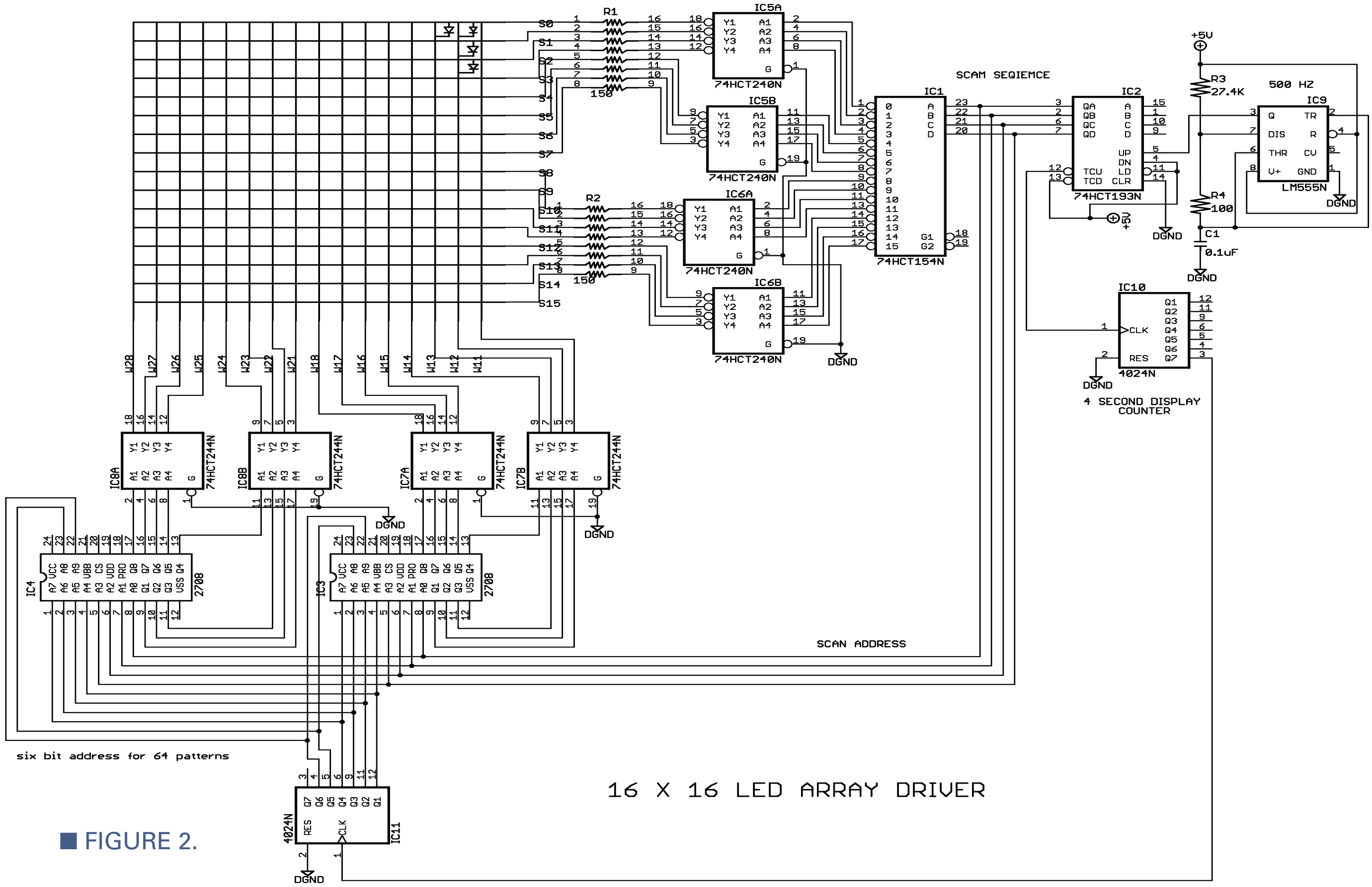
■ FIGURE 1.

LED ARRAY DRIVER

Q I would like to be able to display changing random patterns of lights on an LED (10x10 or 16x16) matrix by using four preprogrammed EPROMs (2708s, 2716s, or some other chips): two for sourcing and two for sinking. A clock circuit should be on the board, but it should have the ability for a user-variable rate of speed. The LED matrix should be a separate board connected to the driver board with a ribbon cable. You have always been very helpful. I would greatly appreciate any suggestions for a circuit that would do this.

— Bob Christopher

A For my solution, see **Figure 2**. The clock, IC9, drives the binary counter, IC2, which — in turn — drives the one of 16 decoder, IC1. The decoder outputs go high sequentially from one to 16, and light the LEDs (which are enabled by the control lines at the bottom) from top to bottom in 1/30th of a second. IC5 and IC6 are drivers to supply current to the LEDs. If it were any slower, you could see the scan rate. The 555 astable (IC9) runs at 500 Hz minimum and can be speeded up by R3. The four-bit counter (IC2) provides the 16 numbers to scan the array. I was puzzling over how to synchronize the vertical scan and the EPROM addresses when my grandson,


16 X 16 LED ARRAY DRIVER
SCAN SEQIENCE
SCAN ADDRESS
six bit address for 64 patterns
4 SECOND DISPLAY COUNTER
500 HZ
+5V
R1
R2
150
R3
27.4K
R4
100
C1
0.1uF
IC1
74HCT154N
IC2
74HCT193N
IC3
IC4
2708
IC5A
IC5B
IC6A
IC6B
74HCT240N
IC7A
IC7B
IC8A
IC8B
74HCT244N
IC9
LM555N
IC10
IC11
4024N
DGND

■ FIGURE 2.

Matthew, told me to use the scan word. Eureka! That works and leaves six address lines for 64 different patterns. You could have 128 different patterns by using a 2716 EPROM. The TTL does not have much drive capability, so I am using a 74HCT240 inverting buffer and a 74HCT244 non-inverting buffer to get up to 20 mA drive to the LEDs; 150 ohms in series ensures that the current will not be excessive.

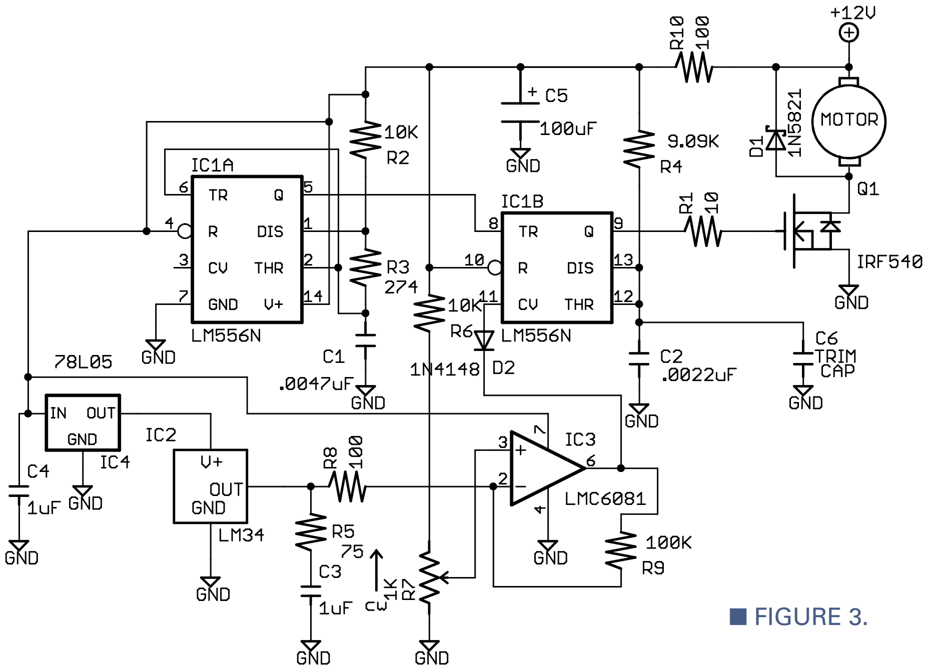
The pattern needs to be displayed multiple times in order for the brain to see it, so the seven-stage counter (IC10) increments the address after 128 scans (about four seconds' time). You can decode a different number from IC10 for a smaller time or use a 12-stage counter (CD4040) for a longer time.

FAN SPEED CONTROL

Q I need to power-up and control a 12V squirrel cage blower motor from an automobile. The blower is going into a segment of my heating system and I want to control its speed based on ambient temperature — in a linear fashion from about 60°F to 75°F — so it's higher speed at lower temperatures.

The blower draws 12 amps at 12 volts; I will need a power supply for that. I would like to use a microprocessor if you can do it.

— David Abineri


+12V
R10
100
MOTOR
D1
1N5821
Q1
IRF540
R1
10
C5
100uF
GND
10K
R2
9.09K
R4
IC1A
IC1B
LM556N
TR
Q
R
DIS
CV
THR
GND
V+
R3
274
10K
R6
1N4148
D2
C1
.0047uF
C2
.0022uF
C6
TRIM CAP
78L05
IN
OUT
IC4
C4
1uF
IC2
OUT
LM34
R8
100
R5
75
C3
1uF
CW
1K
R7
IC3
LMC6081
100K
R9

■ FIGURE 3.

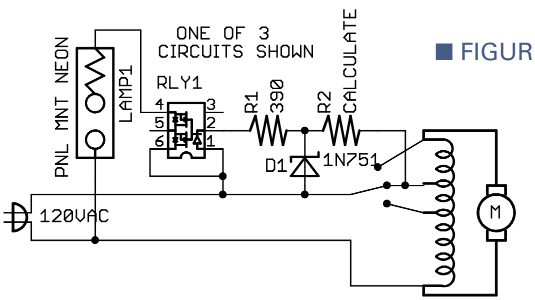


FIGURE 4.

PART	DESCRIPTION	MOUSER PART NUMBER
LAMP1	RED LAMP	362-R9-40N4-05-RR9-40N4-05-R
LAMP2	YELLOW LAMP	362-R9-40N4-05-YR9-40N4-05-Y
LAMP3	GREEN LAMP	362-R9-40N4-05-GR9-40N4-05-G
RLY1	200V, 100mA	782-LH1510AAB
D1	ZENER, 5V, 20mA	610-1N751A

RESISTORS ARE 1/4 WATT

A For the power supply, I recommend the Mean Well open frame supply from Jameco; part number 213681, $39.95.

The efficient way to speed-control a motor is with PWM, but I don't know how to do that with a micro. The software has a PWM command but the pulse duty cycle is fixed; it does not accept a variable. The output pin is variable but that is not useful. Besides, the 555 timer does do PWM easily, so that is the way to go.

In **Figure 3**, I use a 556 dual timer; the A section is an astable clock for the B section, which is PWM'd by the voltage on pin 11. IC4 is a five volt regulator for the LM34 temperature-to-voltage converter. The R5, C3 network is the recommended compensation that is needed when the line from the LM34 to the circuit is long. The pot, R7, allows you to set the nominal fan speed and the gain of the op-amp is calculated to give maximum speed variation over the temperature range. The diode, D2, prevents the op-amp from driving the CV pin higher than the nominal 2/3*VCC which would attempt to make the duty cycle more than 100%. When the duty cycle exceeds 100%, IC1B is not triggered every clock pulse and the frequency is divided by two. If this happens, R4 should be reduced slightly.

FAN SPEED INDICATORS

Q I am trying to add light indicators for high, medium, and low speed on my inexpensive stand fan but when I connect them to the switch, they stay on all the time; something about the motor windings? Can you show me how to correct this problem?

— Daniel Whittenburg

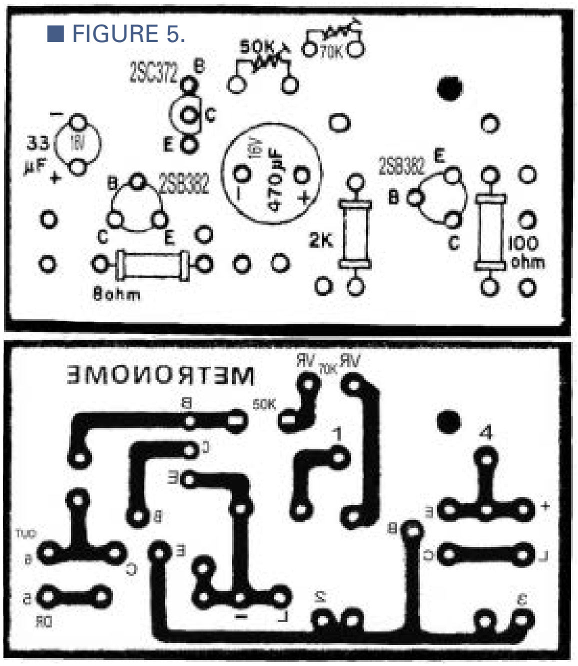


FIGURE 5.

A The speed is controlled by taps on the motor winding which is like a transformer, so there is voltage on all the taps when any one is powered. I think the solution is to connect the indicator across the switch so that the selected one is not lit. Since the voltage will be low and variable, a relay and dropping resistor will be needed; see **Figure 4**. I am using a solid-state relay and low power lamp (neon) to save space, cost, and power.

On the positive alternation of the AC, the five volt zener diode provides a fixed 10 mA current to the LED in the relay; on the negative alternation, the zener is a diode that protects the LED from excess reverse voltage. I don't know what the voltage will be when the switch is open, so you will have to measure it and calculate the series resistor value. Choose the higher of the two available readings and use this formula:

R2 in Kohms = (measured voltage – 5 V)/ 20 mA

HELP WITH ARCHER KIT METRONOME

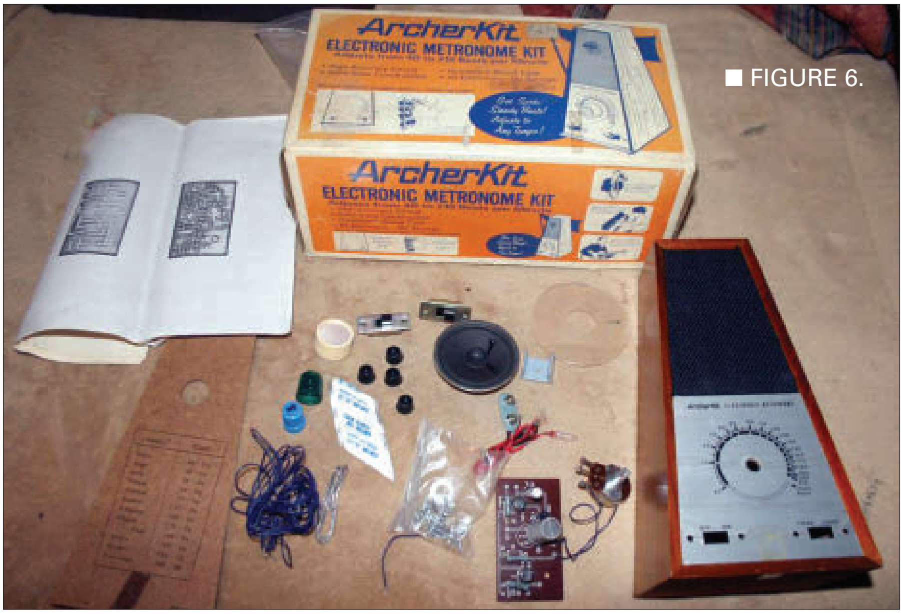
Q I recently found an unfinished Archer Kit metronome in the attic. It was discontinued by RadioShack and I have no instructions for building it. I'd like to finish building it, but don't know where to solder the following: 1) the eight ohm speaker; 2) the 9V power supply; 3) the broken mini lamp; 4) the DPDT on/off slide switch and the DPDT tone/lamp slide switch; and 5) the specs for the mini lamp in terms of V and I.

I have a DC adapter rated 7 VDC at 30 mA; is it optimal for this metronome? Can you reconstruct the schematic for it from the board so I can finish building it?

Is the mini lamp similar to All Electronics CAT# LP-3 (1.5V @ 40 mA) or CAT# LP-4 (3V @ 55 mA)?

— Michael Williams

A I am sorry that I can't be of more help but I don't know how this works. It is some kind of blocking oscillator and I think (see **Figure 5** and **Figure 6**) if you connect neg nine volts from the 70K pot (which is the one to be mounted on the front panel) and positive to the common line at the bottom, it may oscillate. The speaker is apparently connected to the "out" terminal on the left. I don't know what the transistor on the right is for, or how to connect the two switches. The DC adapter is probably good. Your guess is as good as mine on the lamp specs. If you get to the point of hooking it up, if it lights and doesn't burn out it is good. A reader may have the instruction manual; if so, I will let you know.



■ FIGURE 6.

QUESTION ON TRANSFORMERLESS POWER SUPPLY/JUN '12

Q I follow your column every month with great interest. If my reasoning is correct, the reason for the C1-C3 capacitors is to introduce a phase angle which will lower the power dissipation that would result without them. What I don't understand is how you determine the ratio of XL:R1.

— Mel Menders

A Thanks for asking. The capacitor is dropping most of the voltage, so it is the dominant phasor. I ignore the phase angle and use:

$I = 120/(Xl + R)$

To be more accurate, the equation should be:

$I = 120/(Xl^2 + R^2)^{1/2}$.

I also ignore the effect of rectification because it is just too complicated. **NV**

MAILBAG

Dear Russell: Re: Modifications to a Simple Radio, June '12, page 24, Figure 2.

I have four questions since I am not an RF guy:

- C1: How long can the antenna be?
- C2: Is its value 0-59 pF?
- Can L3 and L4 be put on the same diameter plastic bottle if they are spaced 1" from each other?
- Can any amplifier be used if connected to the right of C4? I have a spare NE386 amp.

— Toby Norton

Response: The longer the antenna the better, in most cases. I used to use a 50 foot antenna from my bedroom window to the peak of the barn with good results.

Yes, C2 is a variable capacitor.

L3 and L4 can be on the same form; in fact, that is true of L2 also.

C4 can be connected to any audio amp; the 386 would be good.

Dear Russell: Re: Transformerless Power Supply, June '12, page 26. Cute solution to the problem posed. However, I am troubled by the "no load" condition in the subject circuit. Your two-diode solution presumes that the two diodes are identical in zener voltage, never mind individual thermal effects. The 1N4744A is a 5% tolerance device, meaning that there could be nearly 10% voltage difference between two given devices, whence one would take up all of the load (until it overheated). Better you should have used two 1N4738A diodes connected in series, with each dissipating 860 mW (worst case at 100 mA). The overall voltage across the pair will not exceed the range 14.8-18.0 volts. Then, use a 7812 post regulator (TO-220 package) which can stand the 688 mW dissipation at 18 volts input and 11.4 volts output.

Otherwise, use a zener follower circuit to pre-regulate to ~15 volts.

— Peter A. Goodwin

Response: You are right; thanks for writing. I wish I had done it that way.

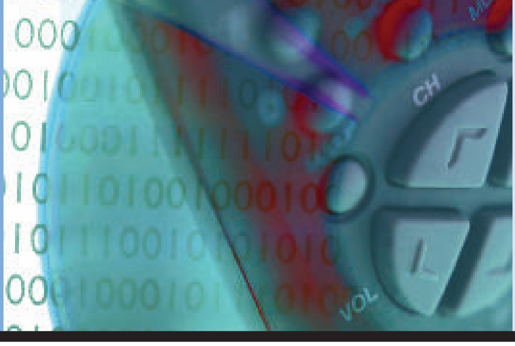
Dear Russell: Re: Multi Input A/V Switch, June '12. First of all, I want to say I enjoy your column; in all honesty it's the second thing I read after the Tech Forum. I have been in the electronics field — two-way radio in particular — and feel that no matter what I know there are still things I can learn from others.

With that being said, I have a problem with your answer to Derek Trombrello. He wrote saying that he had 25 video games to switch (sounds like someone with too much time); however, in his query he stated there was composite video and stereo to be switched; he mentioned the normal color coding: yellow-video, red-right audio, and white-left audio; although the article states "The cables are composite A/V (red, white, yellow, and stereo audio)."

The thing that got my attention was five lines that had to be switched. I am at a loss as to why there would be five I/Os unless the video games were putting out HD. If it is composite video, shouldn't there only be three I/Os to be switched; two for audio and one for video?

— Craig Kielfofer

Response: Your analysis is correct, thanks for writing. I was confused as to the number of lines to be switched, but when I sent the schematic to Derek Trombrello, he replied telling me that there were only three lines, video, and stereo audio. By that time, I had already submitted the column so I let it go, reasoning that an excess of lines was no problem.



NEW PRODUCTS

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The ezLCD-304 features 480 x 272 resolution, 65,536 colors, 350 nit brightness, 500:1 contrast ratio, and a four-wire resistive touchscreen. Its intelligent control module is highlighted by a 16-bit microcontroller, four megabytes of Flash memory, USB 2.0, and TTL serial interfaces. The ezLCD-304 operates at a +3.3V supply voltage, draws less than 100 mA, and offers a -20°C to 70°C operating temperature range. Its low cost makes it a credible alternative to vacuum fluorescent displays, STN passive matrix displays, or more expensive complex graphical LCD products.

One piece pricing for the ezLCD-304 starts at $149 each.

A development kit has also been introduced and provides a comprehensive, easy-to-use platform for those designing the ezLCD-304 into an existing or new product application. The kit includes the ezLCD-304, a development board with RS-232, I²C, and RS-485 interfaces, cables, screwdriver, jumper shunts and a 3.7V lithium battery. Pricing for the turnkey development kit starts at $249 each.

For more information, contact:
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DIGITAL GEIGER COUNTER

Images Scientific Instruments’ new digital Geiger counter — the GCA-07 — is expandable and easy to use. It takes real time radiation readings, and displays the Counts Per Second (CPS) and equivalent radiation levels in either Imperial mR/hr or Metric mSv/hr. The CPS data is updated in one second intervals while the equivalent radiation level readings are a three second averaging of the last three CPS readings. CPS readings will fluctuate second by second, because it displays the actual number of radioactive particles detected in comparison to analog meter counters that average radioactivity levels.

Digital
Geiger Counter
GCA-07
58

The GCA-07 digital Geiger counters can be set to take Counts Per Minute (CPM) readings. It displays accumulated counts and equivalent background radiation in either uR/hr or uSv/hr.

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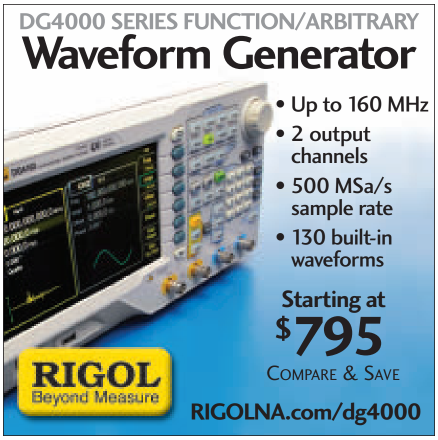
Continued on page 76

SHOWCASE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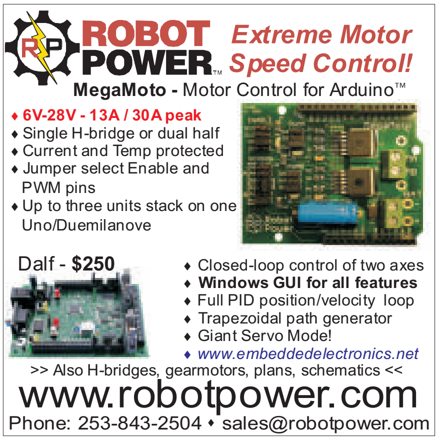
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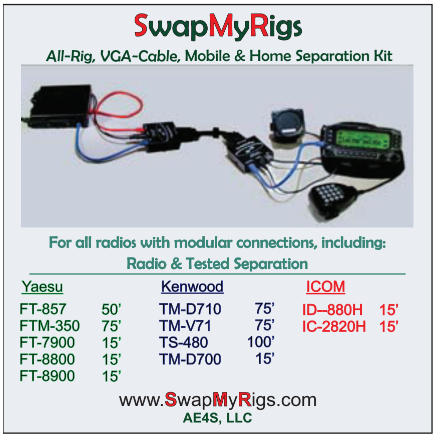
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FT-8900	15'				

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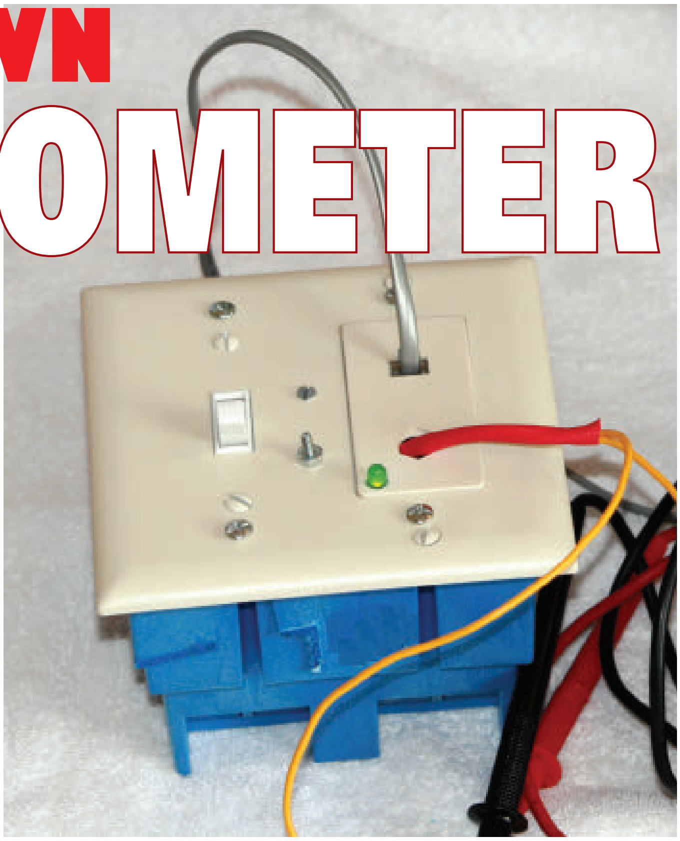
BUILD YOUR OWN MAGNETOMETER



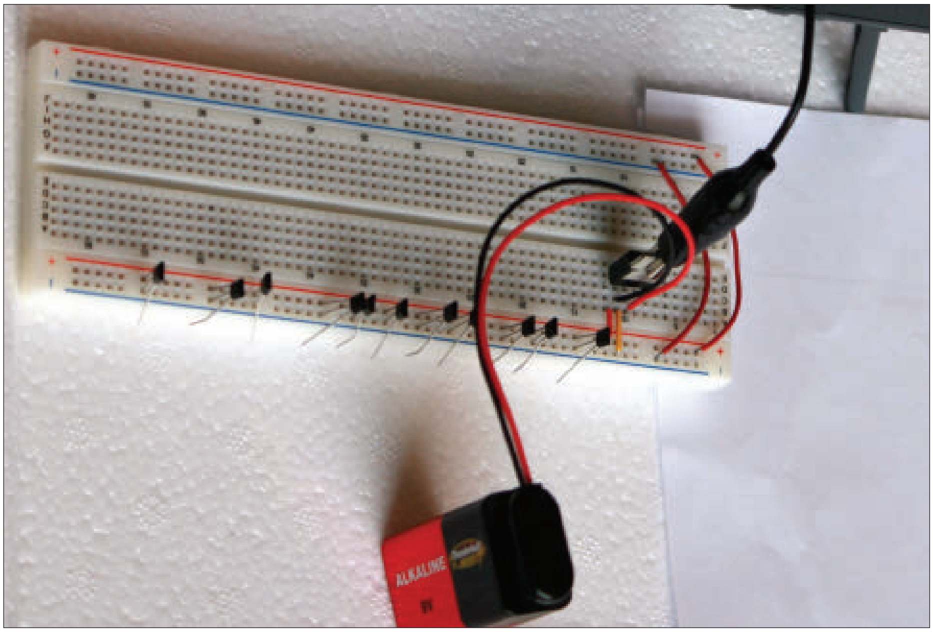
By William Baird

Photos courtesy of Faye Montgomery

One of the neatest gadgets made possible by modern IC technology is the magnetometer. For less than $25, you can construct a fun and durable tool to measure magnetic fields (static or varying) produced by currents, permanent magnets, pieces of iron, or the Earth itself. If you are or were ever fascinated by magnets, this is the instrument for you!

You may have a smartphone with an internal compass that you could use as a magnetic field sensor (assuming you know which end of the phone contains the sensor and what its internal orientation is), but these devices — while sensitive — will usually be overloaded at field strengths much above Earth's. These fields vary with position, but are generally around 0.5 Gauss or 50 microTesla. If you'd like to measure the strength of even a small magnet, the phone may not be helpful.

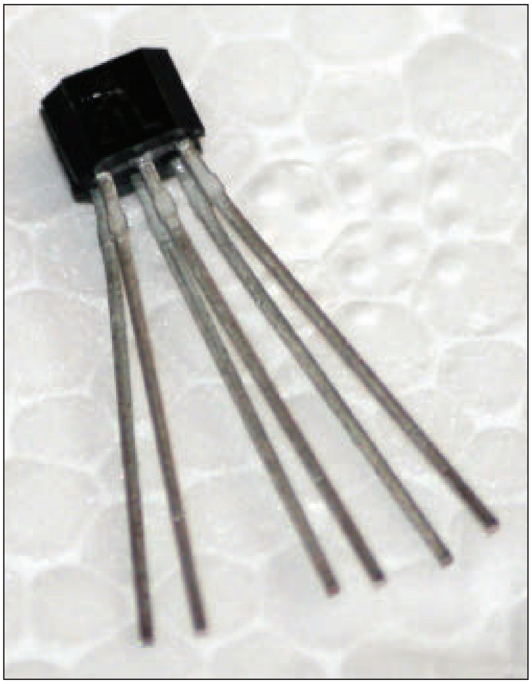
Allegro Microsystems (**www.allegromicro.com**) produces a wide variety of Hall effect sensors that can be used to detect magnetic fields. If you remember



■ **FIGURE 1.** For our magnetometer, we will glue two of these chips back-to-back, and rather than measuring their outputs relative to ground, we will measure the potential difference between the two outputs. Since they are oppositely oriented, this means that an approaching south pole will cause the nearer chip's signal to rise above 2.5V, while the rear-facing chip's signal will drop below 2.5V. Measuring the difference between the two gives us two advantages. First, we double the sensitivity of the arrangement as compared to a single chip. Second — and more importantly — our baseline no-field signal will now be at or near zero volts, rather than at or near 2.5V, meaning we can use a more sensitive range on the voltmeter. If you buy several of these chips, you can match two by powering them all at once on a breadboard and looking for two with the same output.

PARTS LIST

DESCRIPTION	PART #	SUPPLIER	QTY
Electrical Two-Gang Box	70974	Lowes.com	1
Single Pole Light Switch	83080	Lowes.com	1
Cable/Telephone Combo Jack	169763	Lowes.com	1
Combo Nylon Wall Plate	89198	Lowes.com	1
Package 4-40 x 1/2" Machine Screws	491275	Lowes.com	1
7' Phone Line Cord	303008	Lowes.com	1
Heat Shrink Tubing Assortment	16481 HS	Mpja.com	1
Alligator Clip Test Leads	16435 TE	Mpja.com	1
Green 5 mm LED	15110 OP	Mpja.com	1
Allegro 1325 LUA Hall chips	89T7955	Newark.com	2
9V Battery Clip	94F1482	Newark.com	1
9V Battery Snap Connector	31M0724	Newark.com	1
7805 Voltage Regulator	69R5614	Newark.com	1
1,000 Ω resistor	60R3433	Newark.com	1

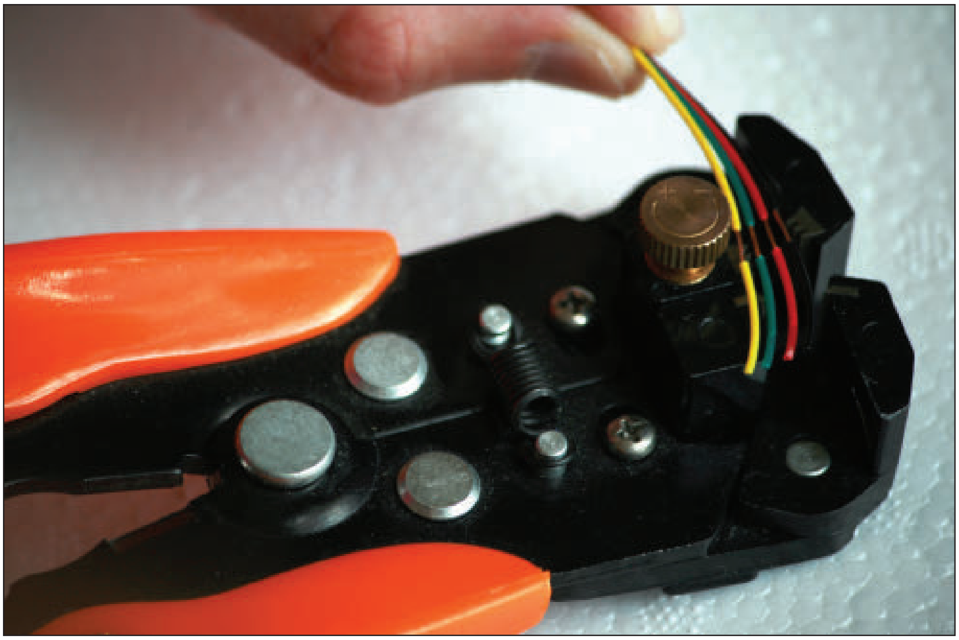


■ **FIGURE 2.** Since they all have the same orientation, are all powered by the same source, and are very close to one another, they should ideally all read the same. In reality, there are slight chip-to-chip differences. You can just move down the row of chips, recording their actual output voltages and then pick the two that are closest to equal. Once you've found two that match, you glue them back-to-back and get the package shown. (As a side note, you could, in fact, glue them face-to-back so they are facing the same way. If you do this, the difference in signal outputs will now represent the gradient of the magnetic field. Instead of telling you how strong the field is, it will tell you how much it changes over that tiny distance of a millimeter or two. If you decide to build one of these, you might want to put a spacer between the two chips so they are a centimeter or so apart.)

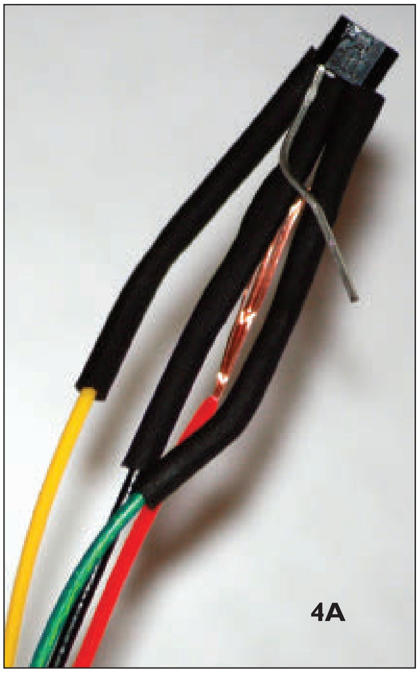
introductory physics, you may only recall that the Hall effect is the definitive way to determine whether a current is caused by the flow of positive charges in one direction or negative charges in the other (as it turns out, if you're working with a solid it's negative charges). These devices can be purchased in three-pin Single Inline Packages (SIPs) that look very much like TO-92 transistors. For this project, these are much easier to work with than the three-pin SOT23-W form factor.

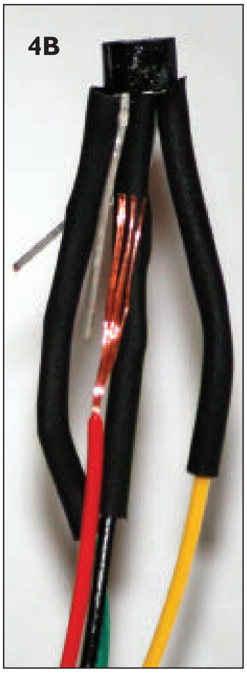
There are multiple varieties of these Hall chips on the market. What you will need is generally referred to as a linear Hall effect sensor. This is in contrast to a binary device known as a latching chip which will be turned on by a field exceeding some strength, and not turned off until an oppositely-directed field of some strength is applied to it. I'm using an A1321 which may be hard to find now, but you can substitute an A1301, A1302, A1324-1326, or any other linear Hall chip (though I have had more success with Allegro than with some other manufacturers).

These chips have about the simplest design possible; when reading the numbers on the chip, the left leg is incoming power (+5V), the middle leg is ground, and the right leg is an analog voltage that ranges from zero to



■ **FIGURE 3.** In my experience, a self-adjusting wire stripper is the perfect tool for phone lines.



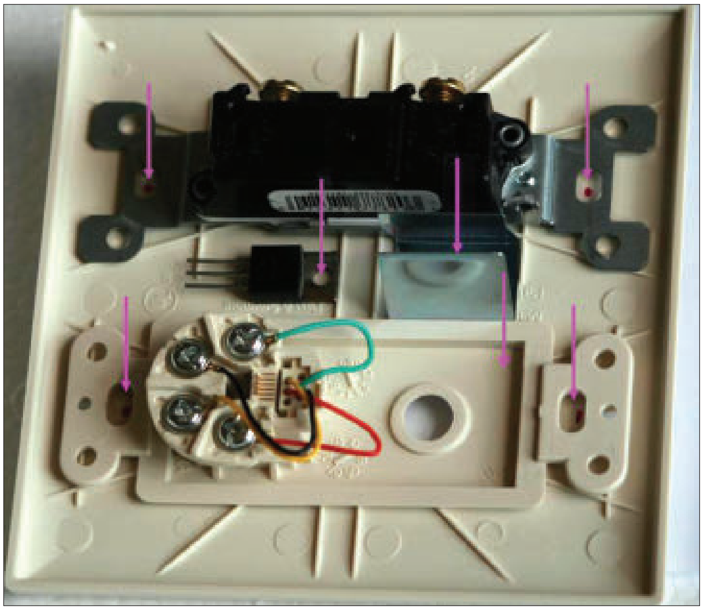


■ FIGURES 4A, 4B, and 5. The connection process is probably what you would expect: solder and heat shrink. The fact that it has to be done in a particular order may not be expected. First, connect one of the phone wires (I used the black one) to the two ground pins which are located on top of each other since both are in the center. Make sure that, after soldering, you slide the heat shrink all the way up the Hall chips. Next, connect each of the signal legs (remember that the signal leg from each chip is the one on the right as you are looking at the numbered face) to its own phone wire (I used green and yellow for this). Here, order is not important — just solder them and again apply heat shrink all the way up. The reason for starting with ground, then signals, then power is apparent now. The two power legs are on opposite ends of this six-legged package. You'll have to sort-of bend one around the entire package to reach the other, and then connect the pair to your last remaining phone line (red, in my case). You can't use the ordinary small heat shrink for this because it will bring the two opposite legs together so tightly that they will break off. Fortunately, everything else is already covered, so this doesn't have to be. You can use one large piece of heat shrink that covers the entire probe, as shown in Figure 5.

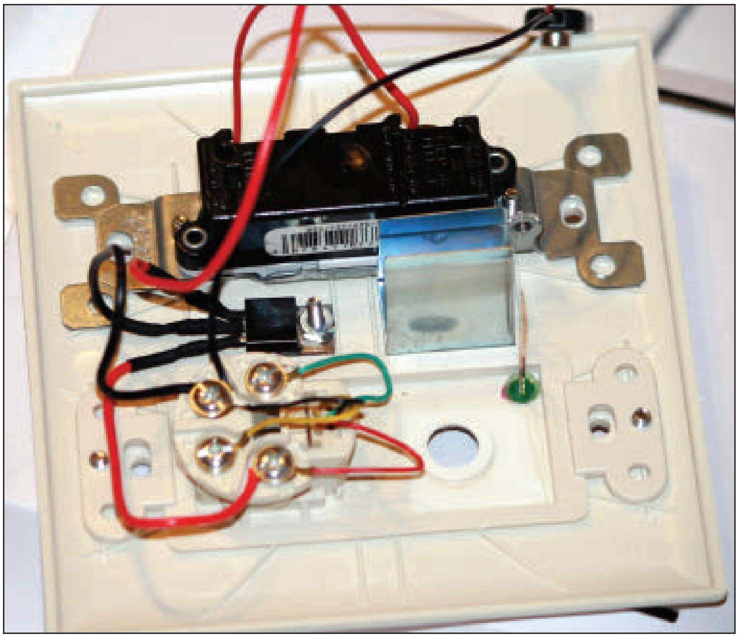
the powering voltage. When there is no significant external field present and the chip is powered by a 5V supply, the output will be 2.5V. For the A1321, moving a north pole towards the face will decrease this value and moving a south pole towards it will increase it. The sensitivity of the A1321 is quoted as 5 mV per Gauss.

The now six-legged package can be conveniently mated to larger connectors that are easier to work with using a regular telephone cord. You don't need a six-wire cord for this, though; the more common four-wire is sufficient. First, cut one of the modular plug ends off of the cord and strip it so that you have a plug on one end and four free wires at the other. Now would be a good time to check the continuity between the exposed phone wires and the terminals on the phone jack itself. It might seem obvious that the red wire will be connected to the red terminal, but all four-line phone cords are not created equal. In some of them, you'll find that red and green (for example) are swapped and that will, of course, change how you ultimately wire things up.

Once the Hall chip is successfully connected to the phone wire and the heat shrink is in place, it's time to



■ FIGURE 6. We need to drill some holes in the faceplate now. You'll use two small nuts and bolts to secure the 7805 and the battery holder to the faceplate, so they need holes. You also need four holes to hold the faceplate to the electrical junction box. You'll need one more for the power LED, and if you bought a phone-only jack as opposed to the combination phone/cable jack shown here, you will have to drill a large hole to allow the alligator wires to pass from inside to outside. Simply unscrewing the cable connector provides a ready-made hole in this combination jack.



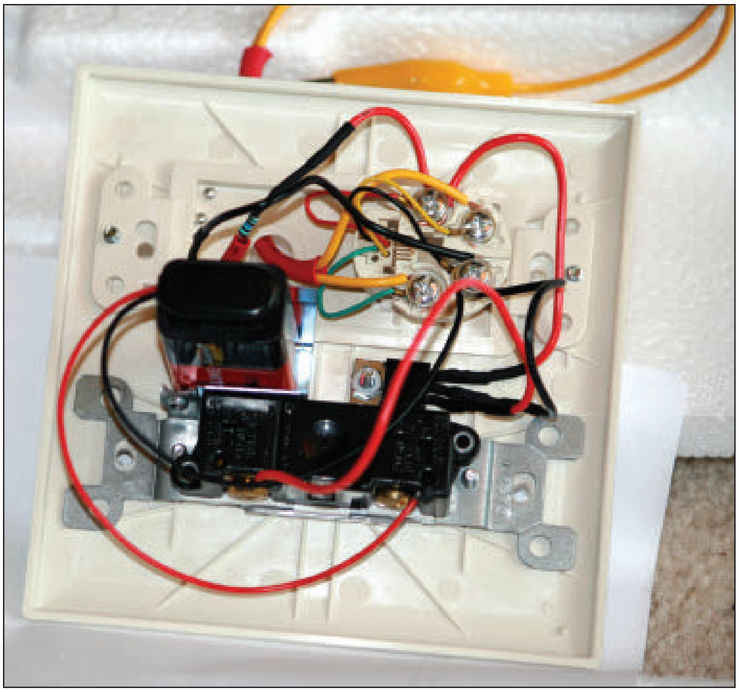
■ **FIGURE 7.** When you have made your holes, you can super-glue the LED in place and attach the battery holder. You can screw the 7805 down for the soldering process, but it might be a good idea to unscrew it and have it lifted away from the faceplate when you are using the heat gun to collapse the heat shrink tubing over your solder joints. The superheated air from the heat gun will deform the faceplate quickly if you aren't careful.

start working on the other end. Basically, you need a five volt power supply, since a nine volt battery is enough to kill the Hall chips. You can use a simple three-terminal 7805 voltage regulator in the TO-220 package. It's easy to work with and already has a hole to allow you to attach it to the faceplate holding the phone jack. When looking at the numbered face of the 7805, the input voltage (nine volts) is connected to the leftmost pin, the middle pin is connected to ground, and the right pin is the five volt output that will go to the proper colored phone terminal block (red, in my case).

You need some kind of power switch to turn it on and off; an ordinary light switch is hard to beat for something low cost and easy to work with. The positive side of the battery clip goes into one of the switch's terminals and the other terminal is connected to the left side of the 7805. Finally, we can add an LED to make on and off more obvious.

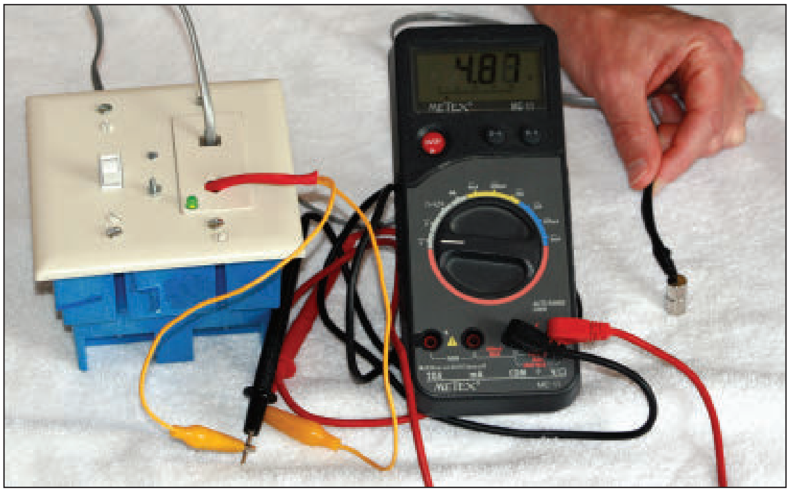
The LED should be connected to a resistor of somewhere between a few hundred and a thousand ohms. The smaller the resistor, the brighter the LED. It doesn't matter whether you connect the resistor to the positive or negative leg of the LED. Assuming you choose the positive leg, you then need to connect the free end of the resistor to either the light switch terminal (NOT the same one that the battery is connected to or you'll never turn the LED off!) or the five volt phone terminal. The negative end of the LED needs to be connected to ground.

A few other things to be aware of include: 1) The heat gun should not be held close to the phone jack, light switch, face plate, etc., for long periods of time or it will warp them; 2) The legs can break off of the dual Hall chip if you aren't careful — they aren't made for repeated bending back and forth at large angles and will break reasonably soon; 3) You might find it useful when testing your work to cut another test lead cable in half and use one of the halves to bring the ground connection outside of the electrical box. Finally, it sounds hard to believe, but one glitch has come up repeatedly over the years that I have helped dozens of students build these: The phone wire will look like it's properly plugged in, but you have to push it in until it clicks to be sure.

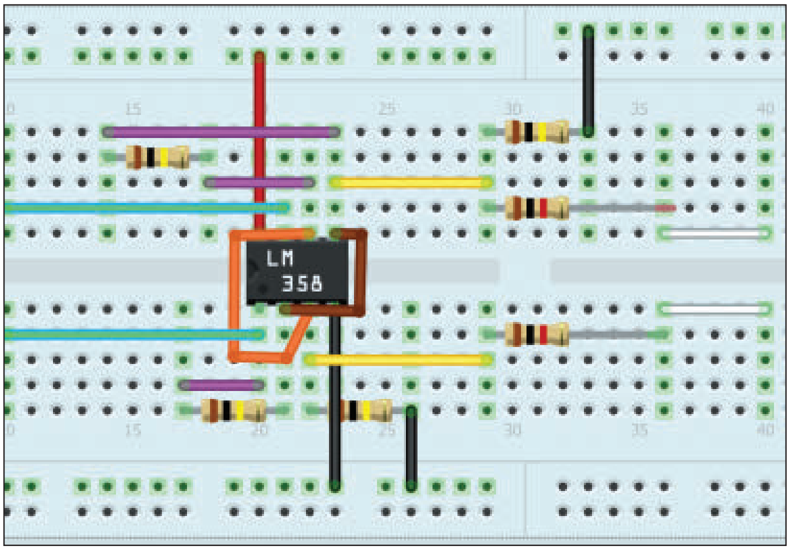


■ **FIGURE 8.** To recap, your connections on the phone terminal block are as follows: On the red terminal, we have the 7805 output and the positive side of the LED-resistor pair. On the black terminal, we have the 7805 ground, the black wire from the nine volt battery clip, and the ground side of the LED-resistor pair. On the other two terminals (green and yellow), all you need to connect are two alligator clip wires. These will ultimately be clamped to the probes of your voltmeter. You should probably bunch the two together using a long piece of heat shrink that spans the hole in the box. That will give you a little strain relief on the cable and make it less likely that the alligator cables will pull loose during normal use.

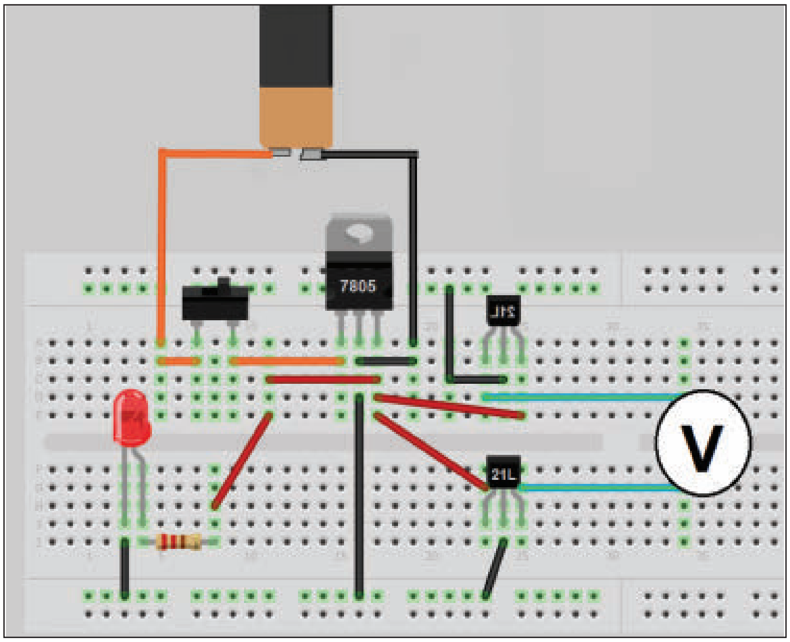
Idea adapted from **http://my.execpc.com/~rhoadley/magmeter.htm**.



■ FIGURE 9. The finished product. Note that the two small Neodymium-Iron-Boron (NdFeB) magnets shown are enough to drive the chips to their limit of approximately five volts. If you flip them over, you will get approximately negative five volts.



■ FIGURE 10. If you would like to amplify your signals, you can use this diagram.



■ FIGURE 11. Schematic of magnetometer if constructed on a breadboard.

Once you've built the magnetometer, you can use it to measure a variety of things. You'll find that ferrous materials that you haven't magnetized will still provide a signal when held near the probe. It's certainly not a very precise compass, but you will probably be able to find the general direction of magnetic North.

This only requires a cheap LM358 op-amp and half a dozen resistors. The two green wires on the left side of the diagram are to be connected to a voltmeter. The two white wires on the right side are to be connected to your magnetometer outputs. For some cases, the gain will be too large. You can reduce the size of the larger resistors (shown as 100K here) and/or increase the size of the smaller ones (1K here). This can be powered by a separate 9V battery. No voltage regulator is necessary in this case.

If your voltmeter is set for AC, you can pick up the magnetic fields produced by electrical appliances. The key here is to split an extension cord so that the two wires are not side by side. If they are, the opposing currents will produce magnetic fields that tend to cancel each other and it will be hard to detect anything.

Once you've built this magnetometer, you may be surprised at the uses for it. Anything that produces a magnetic field is a fair target, and the Hall chips respond to changing fields far faster than mechanical detectors such as reed switches. This means they can also be used as rotation sensors when placed near the edge of a gear. The field when a tooth is directly under the Hall chip will differ from the field when a gap between teeth is directly under it. In this way, you can produce a signal that corresponds to the rotation of a wheel.

You might find that a surprising number of your sensor projects can be completed with some magnets and this detector. If you build one and come up with a neat application for it, be sure to let me know! **NV**

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TALKING T-SHIRT RESPONDS TO YOUR TOUCH

Make This Interactive Costume for Halloween Thrills and Chills!

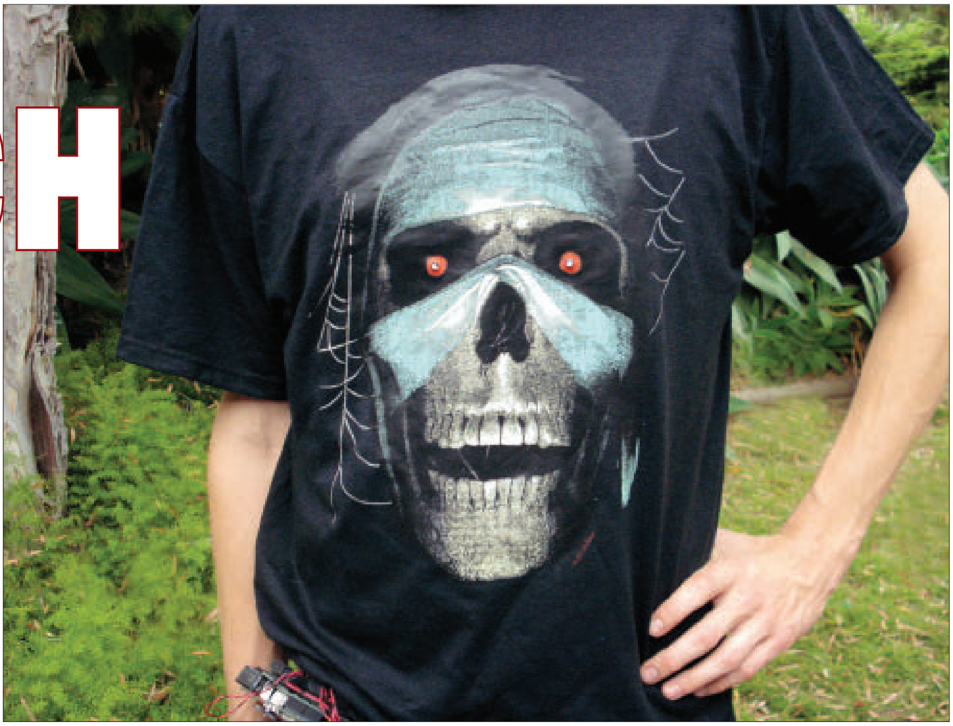


FIGURE 1. This interactive Halloween spook shirt uses an Arduino and an Adafruit Wave Shield to add lights and sounds.

By Gordon McComb

This Halloween, show who's got the best tricks and treats with this fully electronic interactive decorated t-shirt. Embedded inside the shirt are eerily glowing eyes made from ultra bright light emitting diodes (LEDs), a series of buttons for touch sensors, and an Arduino microcontroller equipped for sound playback. Activate a sensor and the eyes flicker ominously while a spooky voice is piped through a hidden speaker.

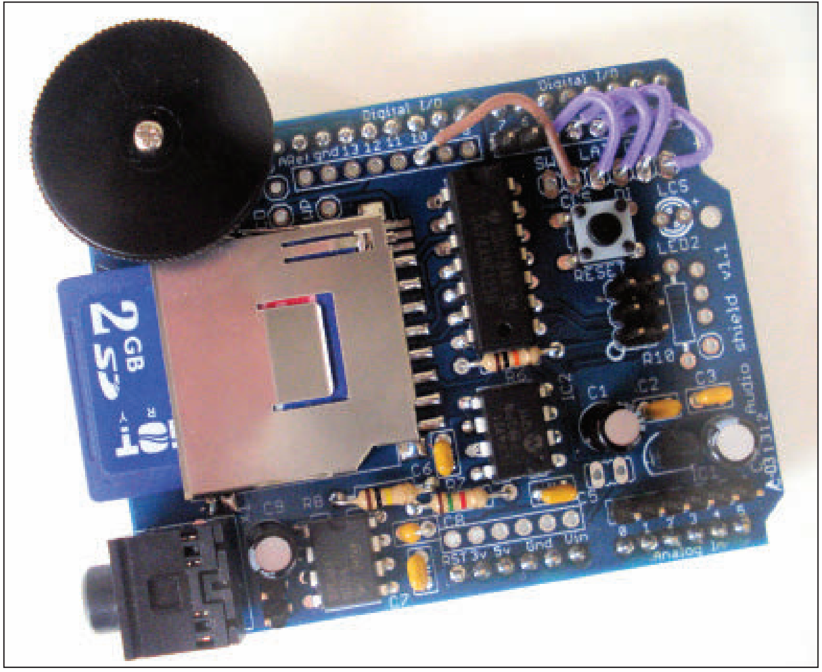
As far as Halloween costumes go, this one's surprisingly easy to make — just an afternoon of light soldering. Because it's intended for just a single night of thrills, I've intentionally designed it so there's no sewing involved. Many "wearable" electronic shirts use conductive fabric that must be carefully sewn into the garment. For this Arduino-based "spooky shirt," electrical connections are made using ordinary wire. The LEDs and pushbutton sensors are temporarily held in place with tape. The Arduino, sound shield, and speaker are attached to a belt loop, and kept hidden under the shirt.

Because construction of the garment is just temporary, you can yank out the electronic guts and reuse them for something else. Decorated t-shirts are inexpensive and made for every occasion. How about a Santa shirt that plays Christmas jingles? Or maybe a tee with an oversized flag that plays patriotic tunes for the next Fourth of July?

While the Halloween shirt described here uses simple piezo discs and pushbuttons, you're free to mix and match other kinds of sensors. Any compact sensor you can connect to an Arduino can be used to provide extra interactivity. That includes ultrasonic and infrared range finders, tilt sensors and accelerometers, and light detectors.

It All Starts With the Shirt

Our Arduino Halloween interactive t-shirt doesn't depend on a specific design. You can use a shirt you already have, or get one especially for this project. Assuming you want to use LEDs as eyes, the design you choose should contain a face or figure of some kind — a



■ **FIGURE 2.** The Wave Shield lets you play standard WAV files using an Arduino Uno (or compatible) as a controller. It has an onboard amplifier, but you'll get a more impressive result if you connect it to an external amplified speaker.

ghost, monster, mummy, zombie, whatever.

I've arranged for a small assortment of professionally decorated t-shirts that fit the bill (available online) in various sizes from adult small to 4XL. Check the **Sources** box for additional info. All are silkscreen printed, and will withstand many washes. The bandages in the Mummy design shown in **Figure 1** use a glow-in-the-dark paint that adds to the thrill factor.

The only required alteration to the shirt is poking a small hole in the center of each eye. The holes allow the LEDs to pop through from the back. Once cut, the shirt fabric may fray over time around the hole. You can reduce or eliminate that by applying a small dab of Dritz Fray Check (available at any yardage or notions store) to the perimeter of the hole.

Building the Electronics

At the heart of the electronics for this shirt is an Arduino Uno (or compatible) microcontroller. Your Arduino needs to use the Atmel ATmega328 chip and not the less capable ATmega168 (this was the chip used in older models of the Arduino).

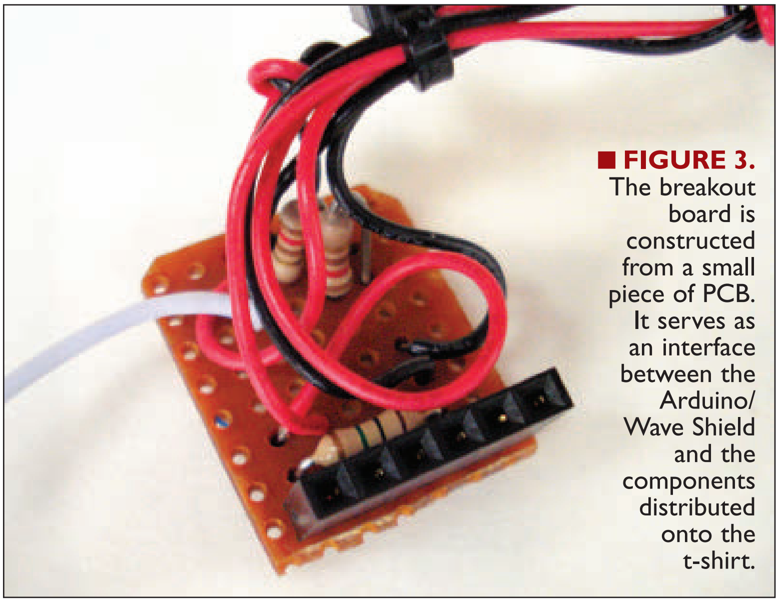
Attached to the top of the Arduino is a Wave Shield board from Adafruit Industries (see **Figure 2**). This low cost ($22) kit adds the ability to play standard WAV sound files through your Arduino. As its name implies, the Wave Shield is a shield board that plugs directly over the Arduino. All electrical connections between the two are made automatically. The Wave Shield comes in kit form, but is easy to assembly. Adafruit provides excellent step-by-step build instructions.

Once the Wave Shield is constructed, double-check your wiring, and then sandwich the shield to your Arduino. Make sure all the pins from the shield are inserted into their correct corresponding connections on the Arduino.

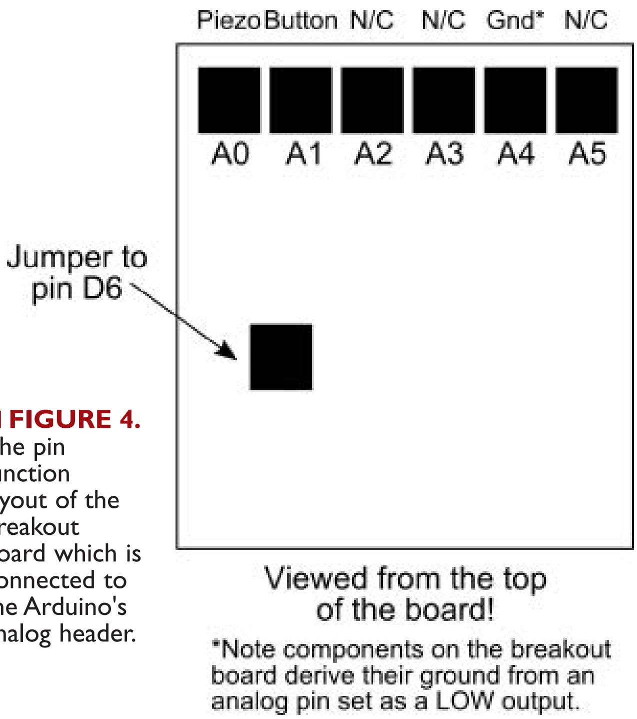
The Wave Shield is equipped with a standard size SD card slot, digital-to-analog converter chip, audio amplifier, and 1/8" jack for attaching to an outboard speaker or amplifier. (I recommend a compact capsule-style amplified speaker, as detailed later.) To use the shield, you merely copy one or more WAV sound files from your computer to a compatible SD card, then slip the card into the slot on the Wave Shield. More on this later.

Several connection points on the Wave Shield are configurable. To complete the wiring of the shield, you must add jumpers as indicated in the online documentation. Unless you have a specific reason otherwise, connect the jumpers to their respective Arduino pins as shown in these docs. That way, you won't have to modify the sketch code. You can use ordinary 22 gauge solid or standard conductor insulated wire for the jumpers. Cut to length to avoid excess.

To complete the electronics package, you must construct a small breakout board for interfacing the Arduino and Wave Shield to the external components that are attached to the t-shirt: the two eye LEDs, plus the piezo disc and pushbutton used as touch sensors. A completed and already-wired breakout board is shown in **Figure 3**. I used a small piece of circuit breadboard,



■ **FIGURE 3.** The breakout board is constructed from a small piece of PCB. It serves as an interface between the Arduino/ Wave Shield and the components distributed onto the t-shirt.


Piezo
Button
N/C
N/C
Gnd*
N/C
A0
A1
A2
A3
A4
A5
Jumper to pin D6
Viewed from the top of the board!
*Note components on the breakout board derive their ground from an analog pin set as a LOW output.

■ FIGURE 4. The pin function layout of the breakout board which is connected to the Arduino's analog header.

cutting it to the size I needed.

Notice the female headers on the board. These connect to a row of male header pins soldered onto the analog pins (pins A0 through A5) of the Wave Shield. The Wave Shield doesn't come with these header pins — you must purchase them separately.

Likewise, a male header pin is soldered to pins D6 and D7 on the Wave Shield (only pin 6 is used here; pin 7 is for future expansion, plus it's easier to solder on two pins than just one!). Pin 6 is used to control the LED eyes and was used as it supports the hardware pulse width modulation (PWM) capability of the Arduino. By using this feature, the eye LEDs can be made to rapidly change brightness, giving them a "flickering" effect.

Figure 4 shows how the pins on the breakout board correspond to the functions of the shirt.

For the eyes (see **Figures 5** and **6**), I used high brightness T1-3/4 size LEDs, mounted to a pair of LilyPad LED PCBs. These are tiny boards designed for the Arduino LilyPad for making wearable electronics. The LED PCBs are a bit harder to find than the standard LilyPad LEDs (which come in standard colors like white, red, and yellow), but they allow you to use any LED by first soldering it to the pad. Look for the LED PCBs at Solarbotics, among other sources. If they're not available, you can use standard LilyPad LEDs, or make your own out of small PCB material cut to size.

I used high brightness ultraviolet LEDs from RadioShack (#276-0014), but most any LED will do, as long as you don't go over the Arduino's 40 mA per I/O limit. Note that because two LEDs are driven in parallel from one pin, you must select a current-limiting resistor for the LEDs that assures the *total* current draw is under 40 mA. Use the standard LED resistor calculation, and multiply by two to get the total draw. Recall the formula is:

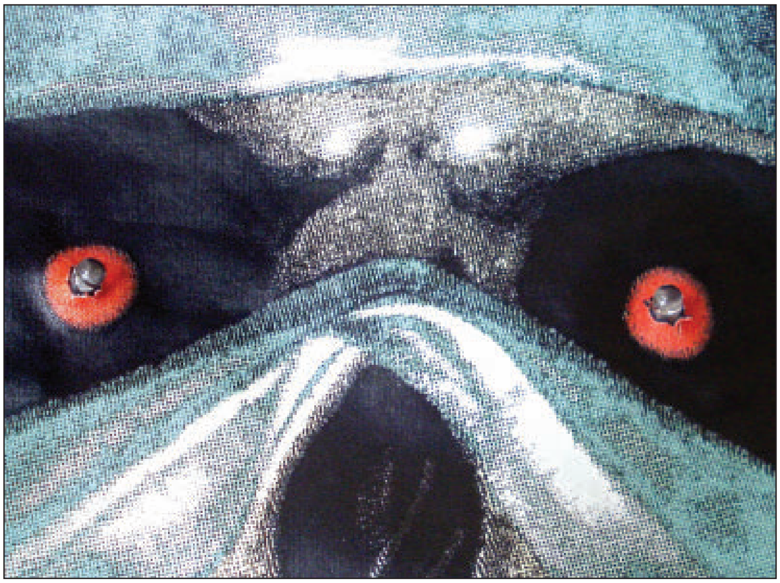
```
R = (Vin - Vdrop) / A
```

where Vin is the voltage applied to the LED (in the case of the Arduino Uno, it's 5V); Vdrop is the forward voltage through the LED; and A is the desired current pulled from the pin, in *amps*. For example, to limit *total* current for the two LEDs at 30 mA (15 mA per LED) and using the specifications for the UV LED I used, the

Have a Safe and Sane Halloween

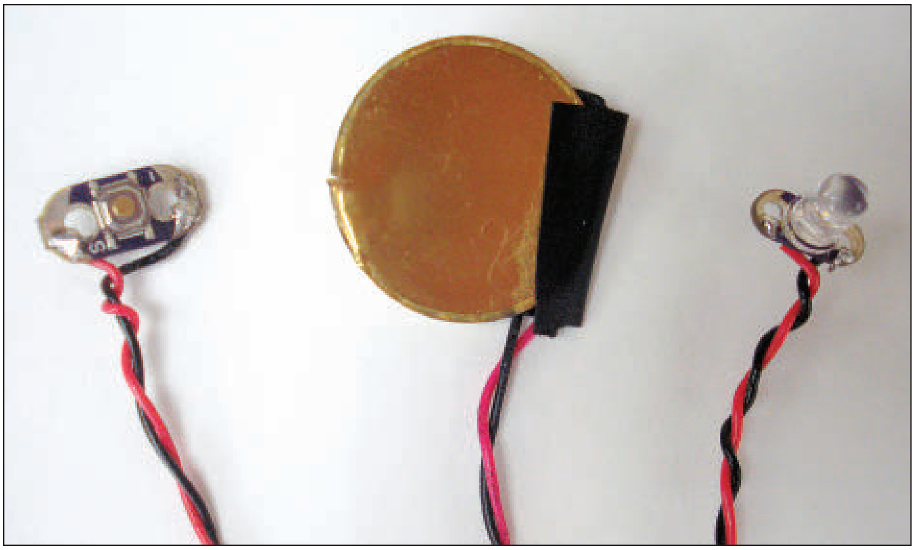
Halloween night provides a great opportunity for frights and fun, but exercise care, too. The Arduino Halloween shirt is intended to be constructed by adults or with adult supervision. Young or old, be mindful of wearing dark clothes when going trick or treating.

If your Arduino Halloween shirt is black or some other dark color, consider adding reflecting strips on the back, so that passing motorists can better see you (or your child). Overall, a white shirt is safer for children, even though it may not be as spooky looking.



■ FIGURE 5. Twin LEDs serve as flickering eyes. Small holes are poked into the shirt, and the LEDs pushed through. Use some Dritz Fray Check to keep the holes from enlarging over time.

■ **FIGURE 6.** The external components used on the shirt include (from left to right): a LilyPad button board; homebrew piezo disc (touch sensor); and LEDs (one is shown here). The LEDs are mounted on LilyPad LED PCBs, or you can mount them on small sections of solderable board.



formula becomes:

```
(5 - 3.3) / .015  = 113
or
3.25 / .015 = 113
```

Select the next higher standard value, which is 120 Ω. **Figure 7** shows the LED and resistor circuit. Solder the resistors to the breakout board (you will string wires from the board to the LEDs in just a bit). The resistors are mounted on the breakout board to reduce bulk at the LEDs.

(Note: You can also use an online calculator such as **ledcalc.com** to do the math for you. Click on the link for parallel LEDs, and enter the data.)

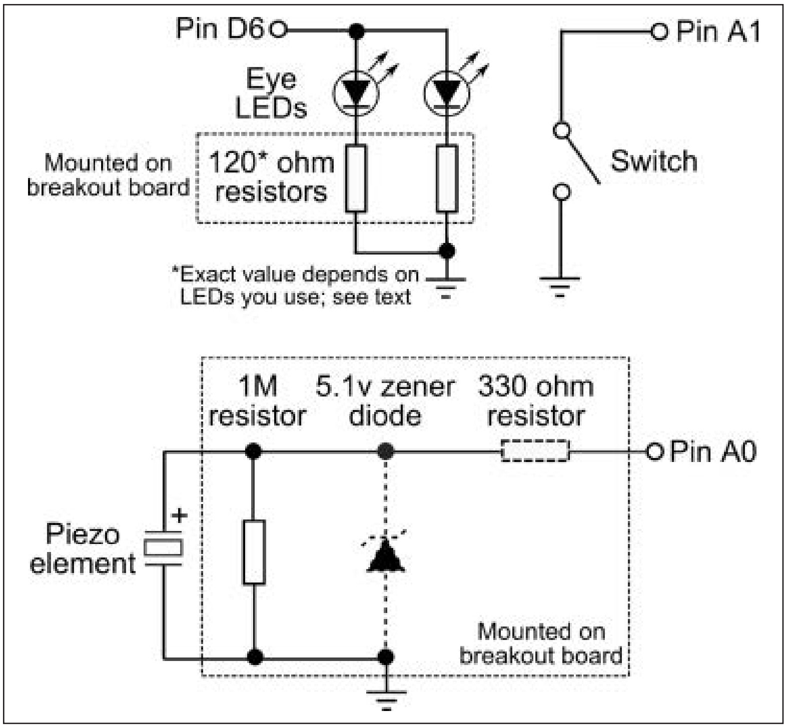
The switch sensor used in the Arduino Halloween shirt is a LilyPad button board which consists of a miniature spring-loaded tactile switch attached to a small PCB. The piezo sensor is constructed from a commonly available 1" piezo disc — check SparkFun or your favorite online surplus seller. The disc must be interfaced to the Arduino using — at a minimum — a 1M resistor to help "bleed off" the charge developed across the piezo element. Check **Figure 7** again for details on wiring up both the button switch and piezo disc.

If desired, you can also add the protective components shown for the piezo disc. The 5.1 zener diode and 330 Ω resistor help prevent the Arduino's I/O pin from being over-volted. They're not strictly necessary, as the ATmega328 chip on the Arduino uses similar circuitry for each I/O pin. Many examples showing the connection of the Arduino to a piezo disc do away with them. Still —

Getting Great Pre-Recorded Sound

The Internet is full of pre-recorded music and sound effects, some of it well crafted and professionally recorded. A simple Web search will locate dozens of sources of free and paid sounds. Or, you may want to skip to the chase and register at **Freesound.org** which is perhaps the Internet's premier site for free open source and public domain sounds.

Freesound allows you to preview any of the clips, then download the ones you like. Though there are some clips with musical elements in the collection, most are sound effects created and recorded using various techniques including pure synthesis, nature recordings, "found objects" (like Coke bottles knocking together), notes from musical instruments, and much more. Typical duration is from five to 15 seconds. Sounds are categorized; check out those in the "scary" and "spooky" sections.



■ **FIGURE 7.** Circuit diagrams for the LEDs, piezo disc, and pushbutton. See the text for the best value for the resistors used to limit current to the LEDs. The components in dotted outline in the piezo hookup are optional, but recommended.

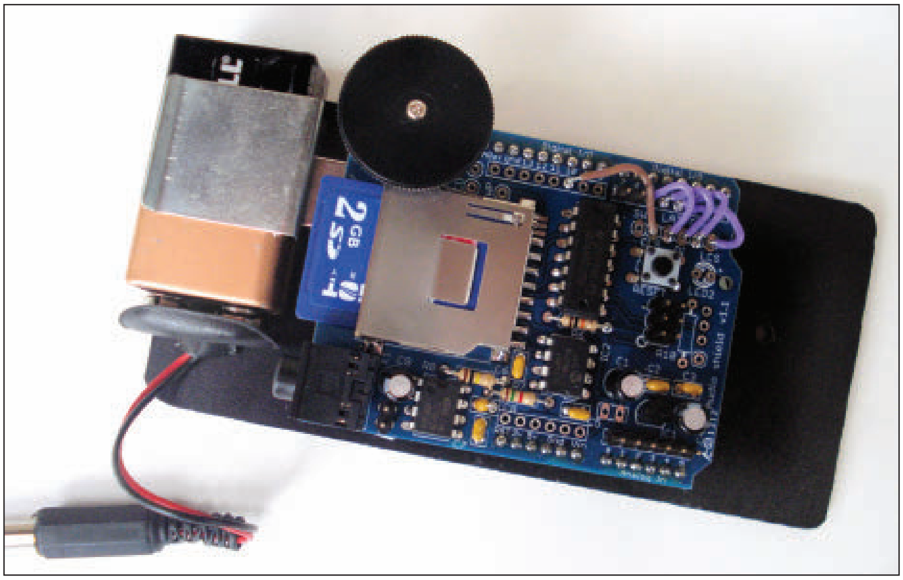


FIGURE 8. The Arduino and Wave Shield mounted on a 1/8" plastic base, with battery. The base is in lieu of an enclosure.

for peace of mind — you may wish to include them.

Following the "keeping it simple" principle of this project, you don't need a fancy enclosure for the Arduino and Wave Shield. Instead, mount your Arduino to a piece of 1/8" plastic or plywood for a base, then use a nine volt battery metal holder on the back as a belt clip, and another holder for the nine volt battery used for power. **Figure 8** shows the Arduino and shield mounted to a piece of black plastic; **Figure 9** shows the back side with the battery holder for a belt clip.

Wiring the LEDs and Sensors

Use ordinary 26 gauge stranded and insulated wire to connect between the external components (LEDs and sensors) and the breakout board. For the LEDs and pushbutton switch, use about three feet of wire. Use a shorter length — no more than about 15" or 20" for the piezo disc — or else substitute with shielded wiring. Twist all wires; this keeps everything tidy and helps reduce the effects of stray signals.

The LilyPad LED boards and button board use extra large holes that serve for both electrical and mechanical contacts. This is to allow extra space when using conductive thread. When soldering with ordinary stranded wiring, apply just enough solder for a good connection. You can use the extra space left over in the hole if you'd like to permanently sew the board to the shirt. Select a thread color that best matches the shirt or decoration, of course.

However, sewing isn't required to mount the LEDs or sensors. For a temporary job, use a "high tack" masking tape as shown in **Figure 10**. This is like regular masking tape, but it uses a more aggressive (stickier) adhesive. Place the LED or sensor where you want and apply several strips of the high tack masking tape to the back of the shirt.

You can also use a strip of white bandage tape. Depending on the tape you use, this leaves a bit more of

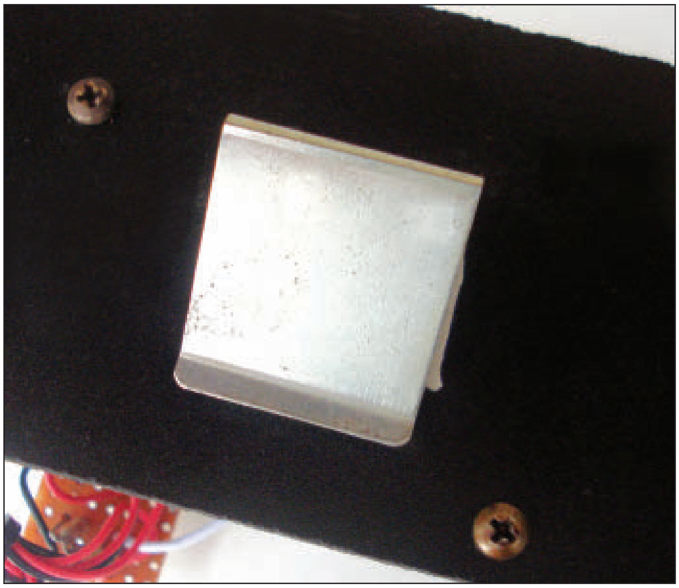


FIGURE 9. Use a nine volt battery holder as a belt clip on the back side of the plastic base.

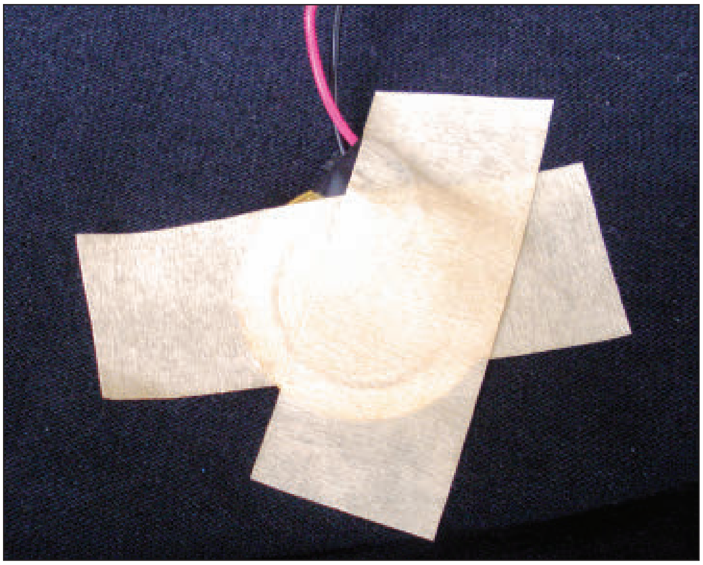


FIGURE 10. Secure the components to the inside of the t-shirt material using high tack masking tape or white bandage tape.

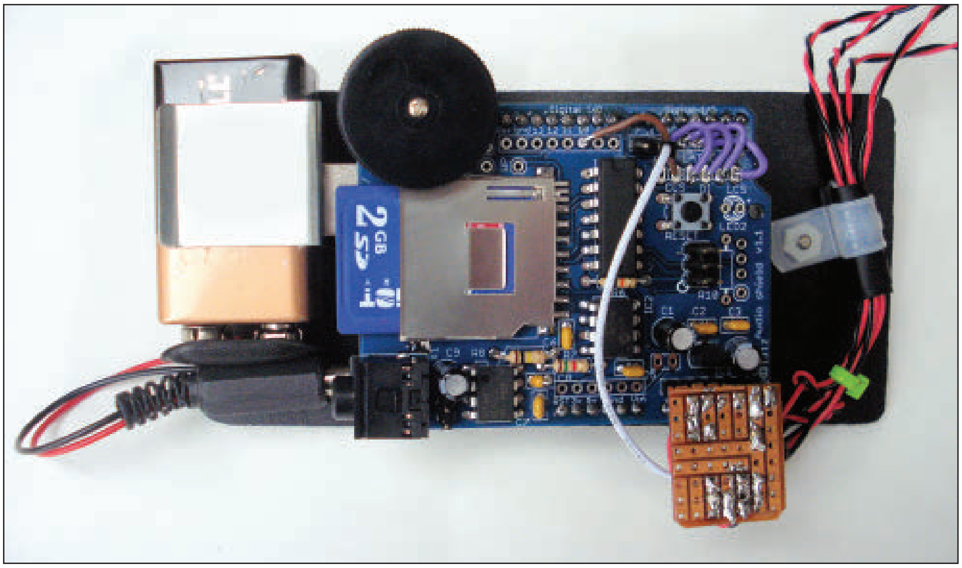


FIGURE 11. The completed electronics for the Arduino Halloween t-shirt, ready to scare someone!

a gooey adhesive when it's removed, but when applied to the back of a clean shirt it provides ample hold.

If you want the component mounting and wiring to be longer lasting, use a pressure or adhesive based fabric fusible interfacing tape, available at any yardage or notions store. Use strips of the tape, and mount or glue it to either side of the components or wire.

Apply adhesive to the cloth of the shirt only, avoiding getting any on the component or wires. This allows for easier disassembly of the shirt for washing or re-using its parts.

Special note! Avoid iron-on fusing tape unless it's the low temperature type. The inks used in many t-shirt decorations are sensitive to high heat. Ironing with too great a temperature — even on the reverse side of the decoration — could cause the inks to smear.

With the breakout board complete and the LEDs and sensors attached, plug the breakout board into the female header you've added to the analog pins on the Wave Shield, and connect up the jumper to pin D6. Your setup should look like the one in **Figure 11**.

Use a nine volt battery (with suitable power plug) to power the Arduino and Wave Shield. A 1/4" plastic clamp keeps the wires to the LEDs and sensors from yanking out of the breakout board.

LISTING 1 — Piezo_Calibrate

```
int sensorPin = A0;    // Piezo element connected to analog A0
int sensorValue = 0;   // Initialize sensor value

void setup() {
  Serial.begin(9600);
}

void loop() {
  sensorValue = analogRead(sensorPin);
  Serial.println(sensorValue, DEC);
  delay(200);
}
```

SOURCES

Click on the Interactive t-shirts link on the left to view suggested sources for Halloween decorated t-shirts and other components for use in this project.
Robotoid.com

Adafruit
Wave Shield
www.adafruit.com

RadioShack
UV LEDs, piezo discs
www.radioshack.com

Solarbotics
LilyPad LED PCBs, button board
www.solarbotics.com

SparkFun
LilyPad LEDs, button board, piezo discs
www.sparkfun.com

Programming the Arduino

The first order of business is to "calibrate" the piezo sensor so that you can find a suitable trigger level that denotes touch. Load **Listing 1** into your Arduino, and open the Serial Monitor window. Systematically press and release the piezo disc, and note the numeric values that appear. A value of 0 means zero volts; 1023 means 5V. Values in between indicate some voltage between 0-5 volts. The harder you press on the disc, the higher the voltage.

Select a value that represents a good, solid contact against the disc — remember to test *through* the fabric of the shirt. If the value you use is too low, you may get false triggers; conversely, if it's too high you may need to exert considerable pressure on the disc in order for the disc to register touch. With the particular disc I used, I found a value of about 550 suitable for detecting touches against the surface of the shirt.

With the desired sensitivity of the piezo disc calibrated, you're ready for the main sketch in **Listing 2**.

This sketch is too long to print here, so it's available at the article link. Before you can compile and upload the program, you must obtain the extra object libraries used in the sketch from their sources. They're included at the article link as well, and from their original sources:

MSTimer2 - *arduino.cc/playground/Main/MsTimer2*
(use the version on this page)
Wave Shield files - *code.google.com/p/wavehc*

Unpack the files into your Arduino sketchbook libraries folder. If this folder doesn't already exist, you'll need to make it. Be sure to restart the Arduino IDE program if it's already running.

Change the line:

```
const int TRIGGER = 550;
```

to indicate the trigger level you wish to use, based on the readings you obtained from the **Listing 1** sketch.

Prepare two sound files, each under about five seconds. The files must conform to the following:

- Standard WAV format
- Monophonic
- Eight- or 16-bit depth
- Sample rate of 22050 or less

You can use a program like Audacity (**audacity.sourceforge.net**) to edit and resample sound files. Use the lowest bit depth and sampling rate that produces acceptable results. Although the Wave Shield is capable of supporting higher sampling rates, it's a good idea to leave some overhead so that the Arduino is not over-taxed when processing sound data. The higher the bit depth and sampling rate, the more data the Arduino must shuttle from the SD card to the Wave Shield's onboard DAC chip. That means there's less time for other programming chores.

Name the files 1.WAV and 2.WAV. The 1.WAV file will play when the piezo disc is activated; 2.WAV will play with the button is pressed.

With the files prepared, copy them to a fresh 1-2 GB SD card, formatted for FAT16 (Windows shows this simply as FAT; other common variations are FAT12 and FAT32). While the Wave Shield will support larger capacity cards and those formatted under FAT32, the smaller ones tend to offer better overall compatibility.

Insert the SD card into its holder on the Wave Shield. Upload the sketch to your Arduino, and

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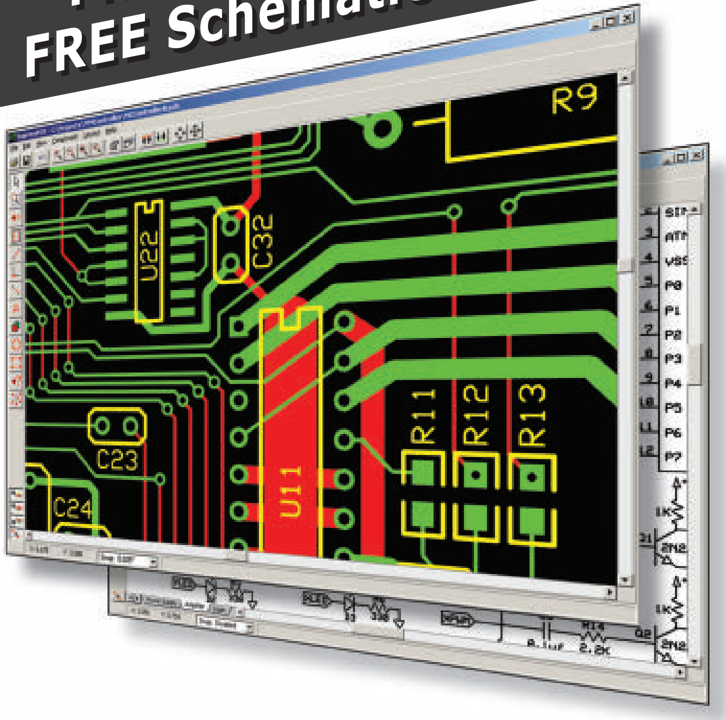

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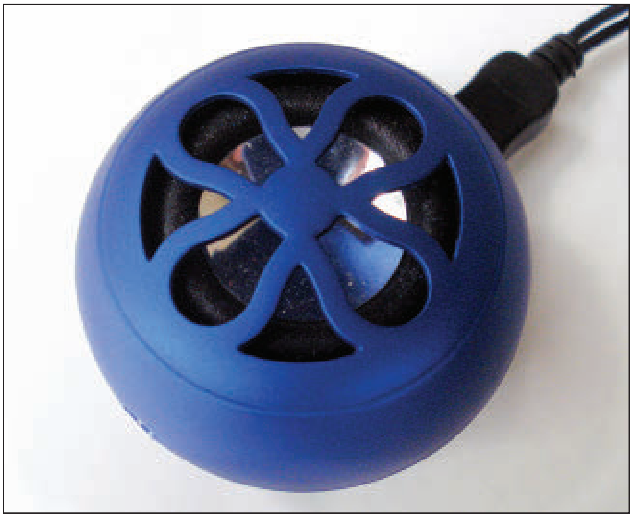


FIGURE 12. Boost the sound output from the Wave Shield with a compact amplified speaker. These have their own internal rechargeable battery and put out a good deal of sound, despite their small size.

open the Serial Monitor window. You should see a sequence of debugging remarks that will indicate if the SD card is found and ready. If you get an error instead, make sure the SD card is firmly seated. Double-check the wiring and try again. If the errors persist, try copying the files to another (preferably different brand) SD card.

Assuming all checks out so far, plug in an amplified speaker — the kind shown in **Figure 12** is ideal. Set the volume control on both the speaker and the Wave Shield to center. Tap on the piezo disc to trigger the 1.WAV sound. Momentarily depress the button switch to trigger the 2.WAV sound. Adjust the volume controls to suit. While the sounds are playing, the LED eyes should light up, rapidly changing intensity to mimic a flickering effect.

You can customize the sketch to alter some of its behavior. Check out the constants (these start with *const int*, and are near the top of the sketch) for values that control the minimum and maximum PWM values for the LEDs and other settings.

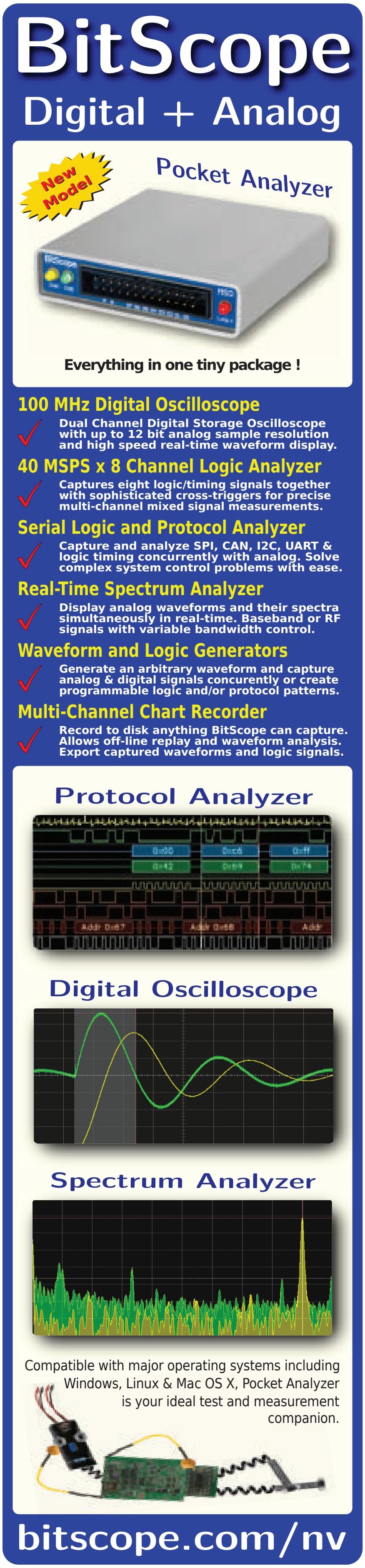
Of course, you can also add more sensors and sound files. Pins A2 and A3 are left open for future expansion (pin A4 serves as a ground connect; A5 is left unconnected and is used to seed the random number generator used in the sketch). Use the existing code in the *loop()* routine as a template for adding more sensors. The value on each pin needs to be checked; if a trigger has occurred, a corresponding sound effect file is played.

Now with your Arduino Halloween shirt programmed, you're ready for some serious trick and/or treating! **NV**

PARTS LIST

1	Spooky decorated t-shirt
1	Arduino Uno
1	Adafruit Wave Shield, with 2x8 and 2x6 header pin set
1	SD card (see text)
1	Self-contained capsule amplified speaker
2	UV (or other color) high brightness LEDs
1	1" piezo disc (see text)
1	LilyPad Button Board
2	LilyPad LED PCBs (optional)
2	120 ohm 1/4 watt resistors (see text)
1	1M ohm 1/8 watt resistor
1	330 ohm 1/8 watt resistor
1	5.1 volt 500 mW zener diode (optional)
1	Nine volt battery
1	Nine volt battery clip to 2.1 mm barrel plug
2	Metal battery clips

Misc: Construction hardware, small PCB for breakout, 26 AWG stranded hookup wire, 1/8" plastic for baseplate, sticky masking tape, header pins for wire connections (see text), double-sided foam tape, Dritz Fray Check.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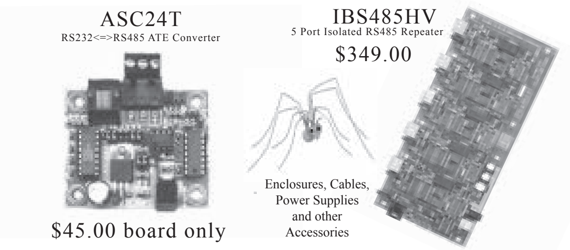

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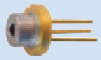

LiteOn #LTLD505T. 650nM red laser diode. 2.4-2.6V operation. 3mm diameter case with lens. 6mm diameter gold-plated heatsink base. Gold-plated leads.

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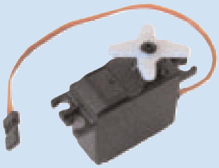

Analog servo motor. Standard size, 1.55" x 0.73" x 1.46" (39.4 x 18.5 x 37.1mm). 49oz-in torque @ 6Vdc. Speed: 0.23sec/60° @ 4.8V, 0.19 sec/ 60° @ 6V. 6.5" leads with standard 3-conductor female connector.

CAT# DCS-110

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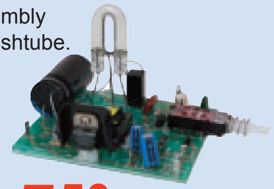

Bright strobe assembly with horseshoe flashtube. Approximately 80 flashes per minute. 12 Vdc operation. 65 x 75mm

CAT# FSH-13

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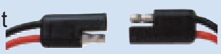

Mating, weather-resistant polarized connectors. 12" red & black 14 gauge stranded wire leads.

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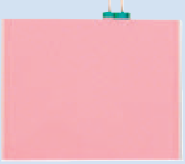

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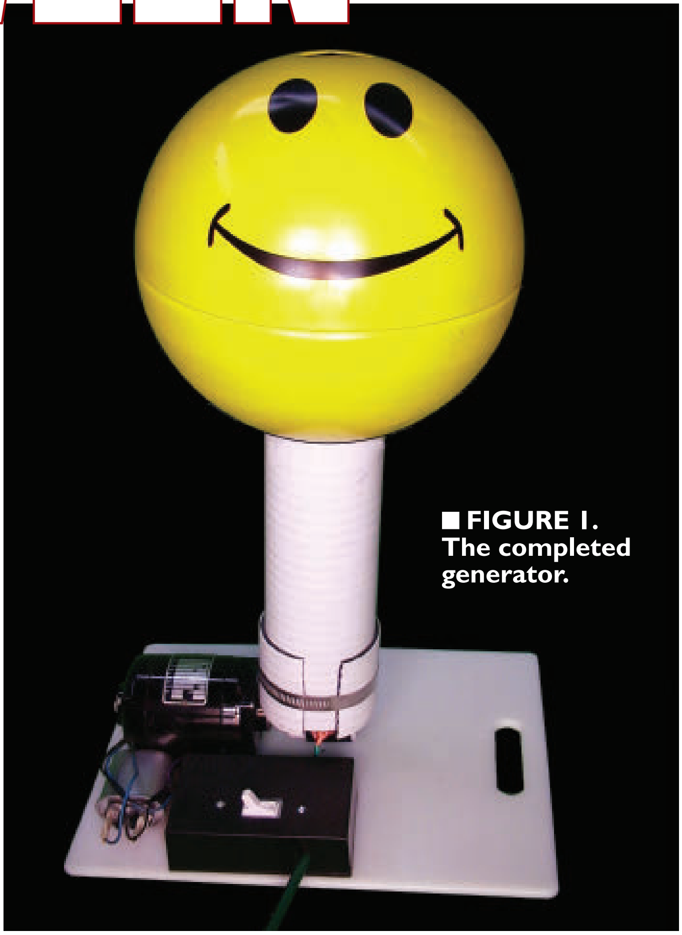
By Walter Noon

A HIGH VOLTAGE HALLOWEEN

This year when the trick-or-treaters reach your door, they may never be the same!

A powerful Van de Graaff generator can be a thing of wonder — producing both a number of strange looking and strange feeling effects! It's also always a chance to educate and inspire an eager mind to the wonders of our favorite hobby: electronic wizardry!



■ FIGURE 1. The completed generator.

I first saw the plans for a wonderful Van de Graaff generator in a reprint of a 1955 publication by C.L. Stong entitled *The Amateur Scientist*. As I recall, what "sparked" my interest right away was that the article advertised that it was possible to create a 100,000 volt generator for $25. That was about my budget — throwing a paper route in high school — but I was quickly astounded by all the wonderful things the generator I built based on that article did!

I think one of the most amazing things about these generators today is that with a few surplus parts, you can *still* build one yourself for about $25! Better yet, with modern materials your generator will not only be simpler, but better!

How It Works

The basic workings of a Van de Graaff couldn't be easier. **Figure 2** shows the basic schematic of a Van de Graaff. The generator consists of little more than a plastic wheel attached to a motor, an insulating column, a conductive top roller, two metal brushes, a rubber belt, and a metal sphere.

Even though these generators produce remarkable energy (on the order of several hundred thousand volts possible), the principle of operation is as simple as that of creating a charge by shuffling your feet on a carpet.

As the bottom roller (plastic) turns, friction between the roller and the rubber belt creates positive static charges on the belt. A small conductive brush mounted at the bottom of the belt is grounded, and serves to remove additional negative charges from the belt.

As the remaining positive charges ride the belt upward, they pass over a conductive metal roller and are collected and distributed on a metal sphere by a second brush.

In theory, the charge on your generator could build up indefinitely. In reality, though, leakage from the sphere to the air limits your maximum charge typically to 100,000–200,000 volts or so. (More on calculating and improving on this later.)

Basic Construction

Construction is very straightforward. Feel free to substitute any materials you choose, and feel free to experiment.

The generator outlined here has proven to be a very solid and simple design, and I've used the design in talks and presentations over the years without fail.

Built as described, this generator will produce a solid one inch (or more) spark to the finger every second or so, and can reach much higher charges if allowed to.

Long hair will stand on end if you touch the generator while standing on an insulator, and it will quickly run motors and all kinds of electrostatic gadgets; including stunts I'll mention later.

Motor and Roller

The motor is a 1,700 rpm 1/40th hp motor which I found in a surplus store for about $15. Virtually any motor will work since the motor is running with almost no load.

I think the two most important parameters to consider in selecting a motor are: the motor rpm, and the diameter of the axle. Though I've built very good generators with motors as slow as 600 rpm, higher rpm motors will build up a charge faster and overcome leakage problems — especially on humid days when Van de Graaffs perform very badly in general.

In my personal experience, motors of over 5,000 rpm have caused my belts to "flap," and required a speed control to work well. However, if you are out to build the *optimum* powerhouse of a generator, high-power commercial units generally try for belt speeds of up to 6,000 feet a minute! Interestingly, belts speeds above 6,000 feet a minute tend to blow electrons off the belt, and you wind up with diminishing returns.

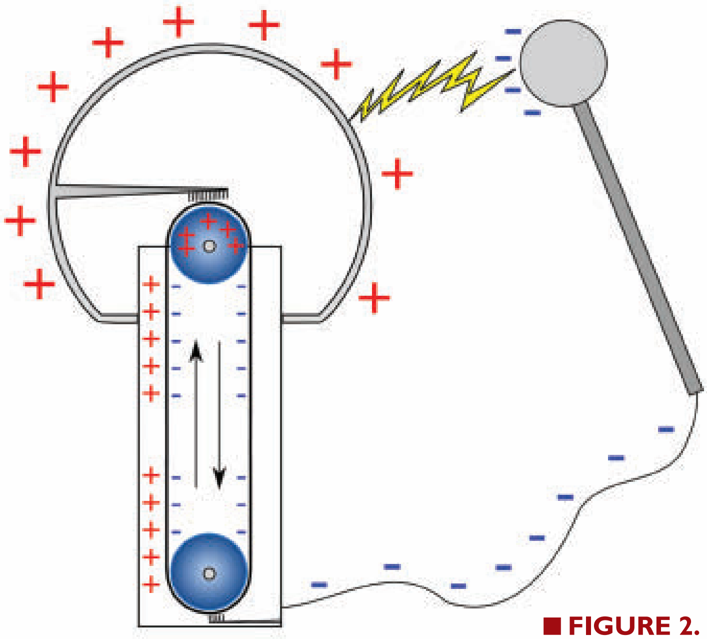
With regards to the motor axle size, I used a plastic wheel from a furniture roller (**Figure 3**) for my lower wheel. So, I simply looked for a motor with an axle slightly larger than the axle on the roller so that the wheel could be drilled and "friction fitted" on the motor axle with a few hammer taps.

Column

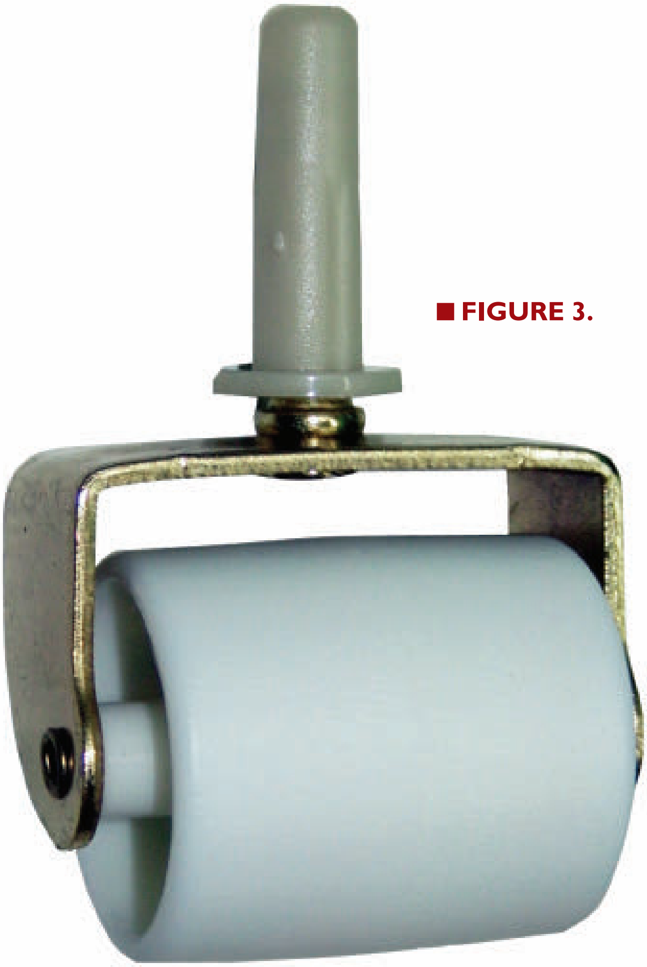
The insulating column is simply 3" PVC sewer pipe. ABS pipe is not optimum (though it will work) as the black coloring is slightly conductive. Acrylic or phenolic pipe might provide even better performance, and are handy being see-through.

Figure 4 shows a reverse view of my simple metal support for the column, and a PVC sleeve I sliced lengthwise and bolted to the support as shown. This sleeve — combined with a hose clamp — keeps the column ridged and straight, while also allowing you to slide the main column up and down to accommodate different belt sizes, and to adjust tension on your belt.

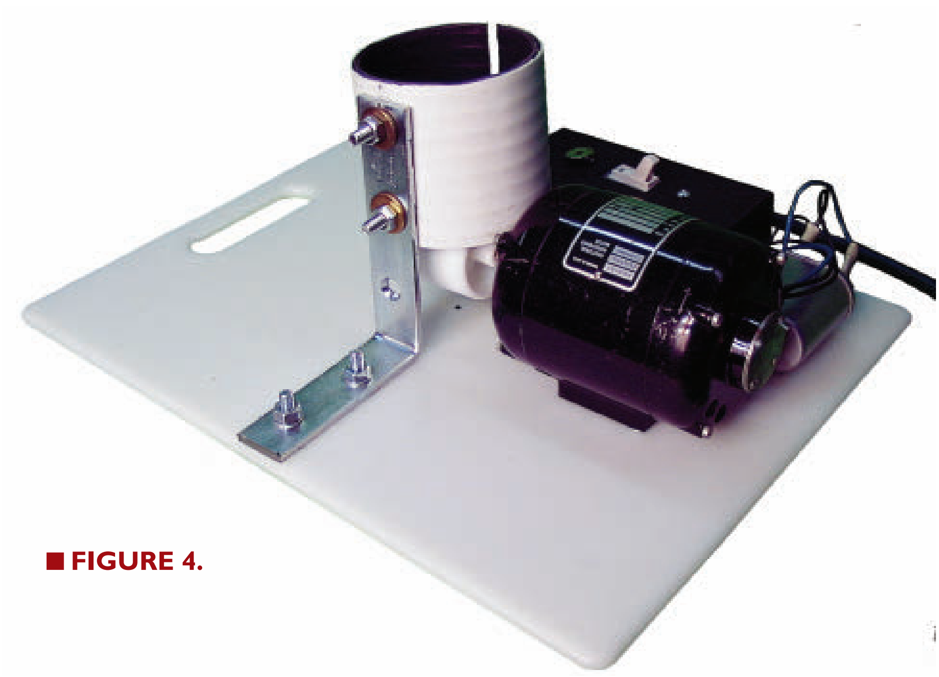
Photo credit: Dake and Wiki commons.



■ **FIGURE 2.**



■ **FIGURE 3.**



■ FIGURE 4.

Top Roller and Brushes

Figure 5 shows the top roller and brush. For my top roller, I used an old bicycle hub being tossed out at the bike shop. *Ideally*, it would be nice to use a bike hub with sealed bearings. Because a bike hub spins vastly faster in a Van de Graaff than it was designed to on a bike, if there is any light oil inside, it will be spun out and entirely ruin your Van de Graaff belt.

Important note: Any oil at all in your Van de Graaff should be avoided! The electrostatic charge will attract the oil to the belt, ruin the belt, and contaminate the rollers.

If using an older bicycle hub as I did, simply disassemble and degrease it before using it. I used only an *extremely* thin coating of heavy grease on the bearings internally, and have had no problems.

You'll also note that the brackets holding the bicycle hub are slotted so that the hub can be easily slipped out for belt changes and even tweaked side to side a bit to center the belt if needed.

The top brush is nothing more than a tuft of wire as shown. A lead soldered to this tuft is connected to the outer dome. Optimal performance is gained if the brush makes very light contact with the belt (though the brush will still pick up charges a short distance from the belt) and will preserve belt life.

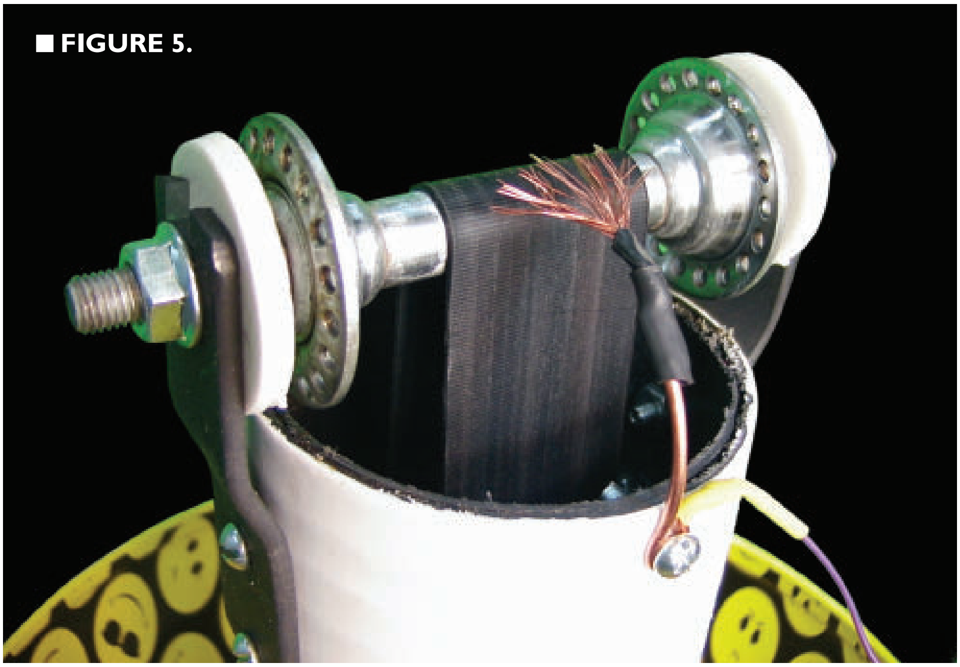
The lower brush is identical and easiest to see back in **Figure 2**. The lower brush should simply be connected to a ground source (such as the ground lead of your three-pronged electrical cord).

Top Sphere

I found my top high potential spherical terminal at Walmart, where it had been mislabeled as a "piggy bank." (You can see the coin slot they mistakenly put in the top.) These pop up from time to time and are worth looking for, though it seems to be a seasonal or promotional item for them. If you hunt around, you're sure to find other objects that will work.

In the past, I've used two stainless steel bowls (available everywhere) face to face to form an excellent and durable sphere. If you do this, be sure to coat all the sharp edges of the bowl with several heavy coats of corona dope, including the hole you cut to accept the Van de Graaff column before assembling. The easiest way to cut a large hole in a metal sphere is with a Dremel tool and cut-off disk; then, file and sand the hole to perfection.

■ FIGURE 5.



Belt

Your belt can be made of nearly any insulator — Rayon, Dacron, neoprene, rubber. I've even used very wide rubber bands with "adequate" results. When looking for a belt, black rubber (such as used in tires) is *usually* not ideal, because carbon is added to get the black coloring and is conductive. Thin belts always seem to give the best performance, but the trade-off is that they take a beating and don't last long.

Commercial belts (available from science supply stores) are usually neoprene and thick. A commercial belt may last 500 hours or more, and has become my belt of choice only because of durability/simplicity. However, homemade belts *often* outperform them.

Probably the best belts I made myself were cut from the wide exercise stretch bands available from Amazon and all over the Internet. You can get a pack for a few dollars that contains several sizes and thickness.

Simply cut out the length of belt you'd like, and super-glue the ends (a diagonal cut on the ends is strongest) to form a truly excellent belt.

Testing

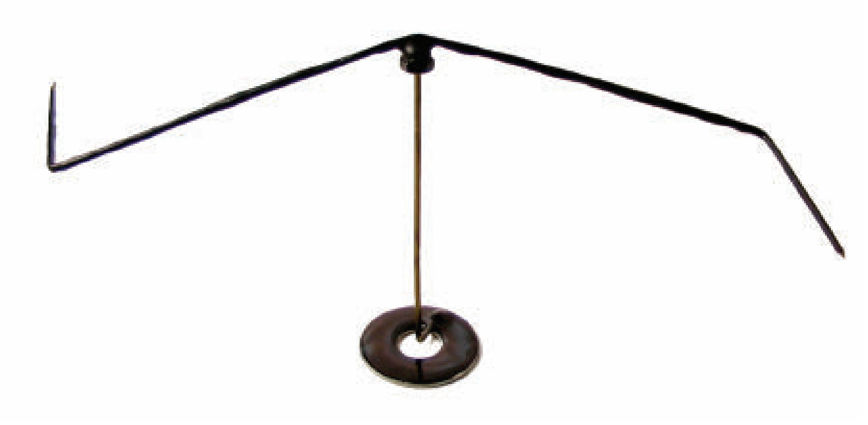
Your generator has many points to help adjust the run of the belt, including the slots on the top roller (allowing you to adjust its tilt) and the hose clamp at the base (for belt length). It usually takes a few minutes the first time you run it to get everything positioned just right. Once you do, your generator should run for many hours without problems.

Keep your face clear of the top terminal while doing this setup, unless you'd like your generator's first bolt to strike there. (Not that I would know, of course.)

A Few Classic Experiments

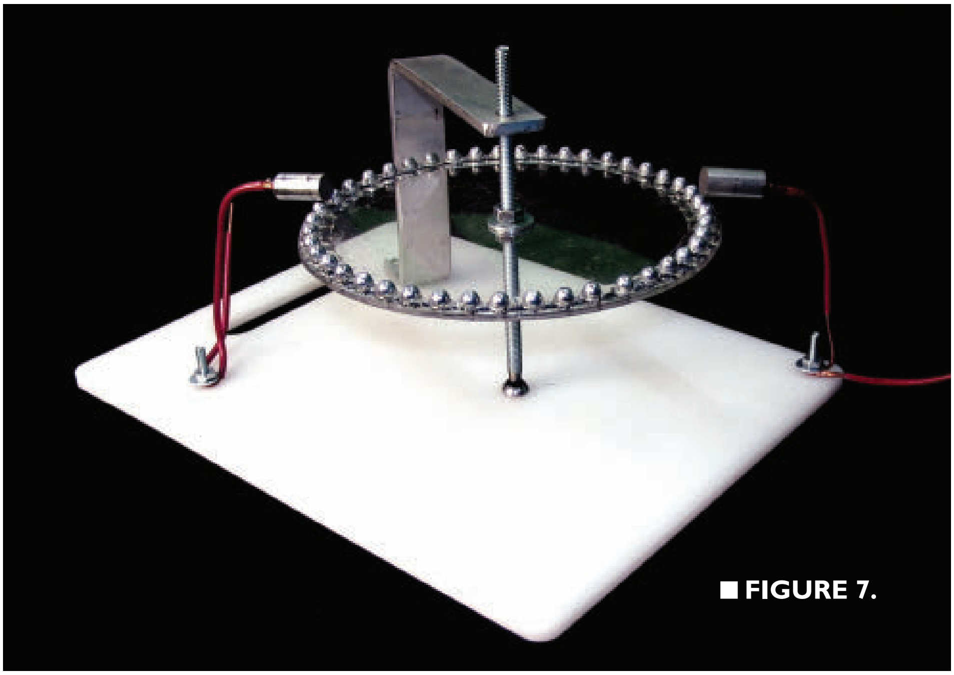
Figure 6 and **Figure 7** show two electric motors that can be run from your Van de Graaff generator. **Figure 6** is an ion motor. A metal bar or wire is bent in the Z shape shown, and the ends are sharpened to a point. This assembly is balanced on a point, forming an easy spinning needle bearing. (I also coated all surfaces with corona dope, except the tips.)

■ **FIGURE 6.**



When placed on top of your running Van de Graaff, the sharp points will have the highest electron density, and the electrons at this point will leak off into the air. Thanks to Newton's Third Law, the motor will spin rapidly. Though the design of this motor is humble, used in frictionless space ion motors have already propelled large rockets such as NASA's Dawn mission to visit asteroids, and at speeds and thrust durations chemical rockets cannot attain. This simple idea may be our best bet for future deep space exploration.

Figure 7 shows a Franklin motor. Invented by Benjamin Franklin, this is possibly the world's first electric motor. Construction is also simple. A set of metal spheres (I used sling shot pellets) are glued around a circle which is balanced on a needle bearing. When spinning, the



■ **FIGURE 7.**

metal spheres pass close to electrodes mounted at either side. One electrode is connected to your generator, and the other to ground.

Though the motor is not usually self-starting (mine has been for some odd reason), given a gentle push it will quickly spin up to high speed. Charges on the positive electrode are attracted to the grounded electrode and move the wheel at often remarkable speeds. It's worth noting that Franklin motors have been made self-starting by adding a small ion motor to the platform.

A Leyden Jar

You can *greatly* increase the power of your Van de Graaff by storing its output in a large capacitor. **Figure 8** shows a five gallon bucket configured as a leyden jar.

Construction is straightforward. Wrap aluminum foil around the outside and bottom of the bucket (as shown) and hold it in place with tape or contact cement. Do the same on the inside. A brass drawer pull on the lid is attached to a chain. The chain makes contact between the drawer pull and the foil inside.

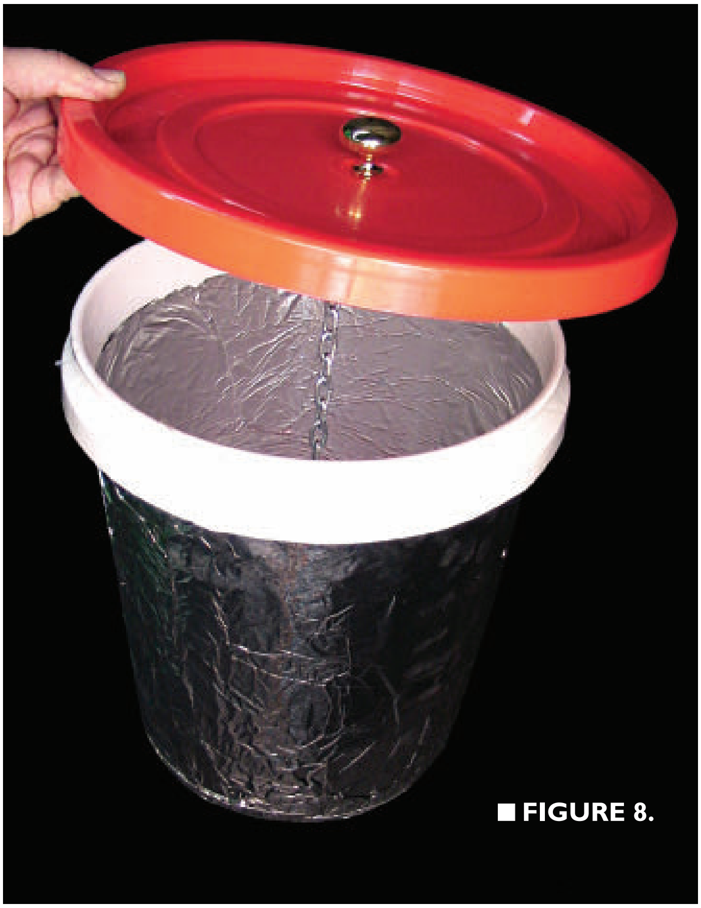
When the lid is placed on the bucket, the outside foil should be connected to ground, and the drawer pull connected to the top of your Van de Graaff. After running your generator for a few minutes, the leyden jar will hold a large charge. To demonstrate this charge, you can short the drawer pull to ground with a discharge pole. **Figure 9** shows a simple discharge pole. A heavy bare wire is attached to the end of a length of PVC pipe as shown. This allows you to stand some distance from the leyden jar holding only the plastic handle, and allowing the metal wire to short the connection between the drawer pull and the side of the jar.

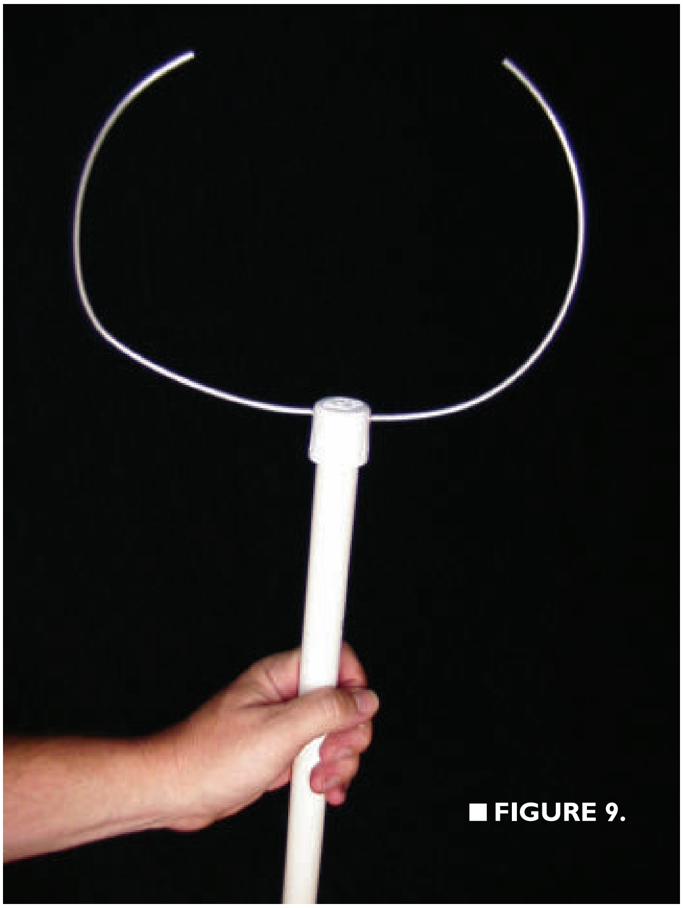
The result will be a thick bright spark and a very loud CRACK. The leyden jar makes many higher energy experiments possible.

Note: Never — under any circumstances — touch a leyden jar without making certain it is fully discharged in this manner. Even if it is not connected to your Van de Graaff, leyden jars have been known to pick up a charge in proximity.

Halloween Magic Ideas

I've seen a very long string of freaky things happen when running my Van de Graaff, and you'll discover these as you experiment. A number of great Halloween door tricks suggest themselves immediately.


■ FIGURE 8.


■ FIGURE 9.

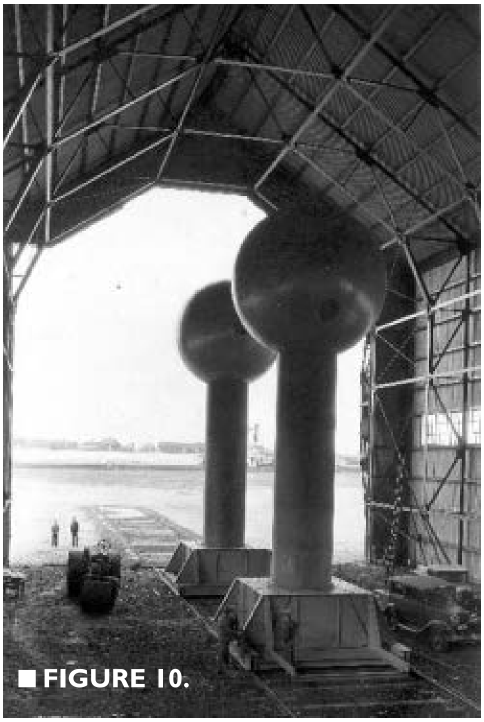
For example, if you bring your arm within a couple feet of the generator all the hair will stand on end. The feeling this creates is hard to describe, but it's quite odd. So, a hidden generator at a safe distance might demonstrate this for trick-or-treaters or party guests.

Of course, a classic piece of Van de Graaff magic is to stand on an insulator, keep your hand on the sphere, and let it gradually charge your body till your hair stands on end. Long dry hair works best.

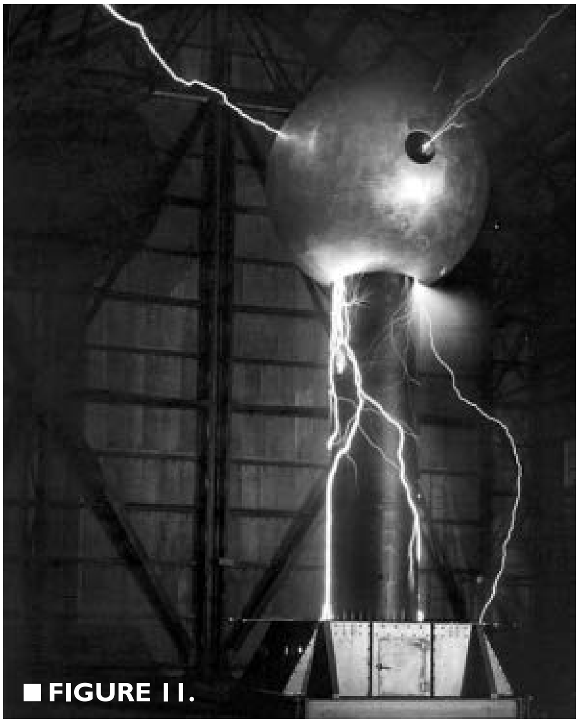
Briefly running your generator can create endlessly entertaining short "pops" to a finger. There really is no limit to what will suggest itself. Just keep in mind when doing any stunt that you'll want a plan to discharge yourself afterward without getting zapped.

A great way to discharge yourself is to hold a metal object at all times (keys are fine) and to then touch that object to a ground source when you are done to remove the charge from your person painlessly.

Remember, NEVER hook up any capacitors (or the leyden jar) to the generator if you or anyone else plans to touch it.



■ **FIGURE 10.**



■ **FIGURE 11.**

Wrap-Up

The question always comes up ... just how far can you "size up" a Van de Graaff?

I'll wrap up with **Figures 10** and **11**, which are two of my favorite pictures. The enormous Van de Graaffs shown were so large that they were placed on railroad tracks and oppositely charged. Potentials of over 10 million volts were said to have been achieved.

I was lucky enough to know Larry White of the Boston Museum of Science. Larry told me that after hours, Dr. Van de Graaff himself used to come in and they would run a one million Van de Graaff (which is still at the museum) for their own pleasure long into the night ... just to watch the sparks and chat. It's nice to know that even the inventor himself never tired of watching his sparks fly!

There are many ways to get more power and experiments from your generator, and some useful computer program calculations. I'll be sure to feature those, and my favorite tips and tricks for *Nuts & Volts* readers on my page at **www.noonco.com/van** I hope you'll send me photos of your high voltage Halloween! **NV**

Robert Jemison Van de Graaff was born at the Jemison-Van de Graaff Mansion in Tuscaloosa, AL from Dutch descent. In Tuscaloosa, he received his BS and Masters degrees from The University of Alabama where he was a member of The Castle Club (later became Mu Chapter of Theta Tau). After a year at the Alabama Power Company, Van de Graaff studied at the Sorbonne. In 1926, he earned a second BS at Oxford University on a Rhodes Scholarship, completing his PhD in 1928.

Van de Graaff was the designer of the Van de Graaff generator — a device which produces high voltages. In 1929, Van de Graaff developed his first generator (producing 80,000 volts) with help from Nicholas Burke at Princeton University. By 1931, he had constructed a larger generator, generating seven million volts. He was a National Research Fellow, and from 1931 to 1934 a research associate at the Massachusetts Institute of Technology (MIT). He became an associate professor in 1934 (staying there until 1960). He was awarded the Elliott Cresson Medal in 1936.

During WWII, Van de Graaff was director of the High Voltage Radiographic Project. After WWII, he co-founded the High Voltage Engineering Corporation (HVEC). During the 1950s, he invented the insulating-core transformer (producing high voltage direct current). He also developed tandem generator technology. The American Physical Society awarded him the T. Bonner prize (1965) for the development of electrostatic accelerators.

Van de Graaff died January 16, 1967 in Boston, MA.

Credit: http://en.wikipedia.org/wiki/Robert_J._Van_de_Graaff

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THE DESIGN CYCLE

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■ BY FRED EADY

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

RIDING 802.15.4 RADIO WAVES

Wire is wonderful. Wire doesn't need external power or batteries to operate. Wire can be used as a conductor, a resistor, a thermometer, a tie wrap, and a fuse. Wire keeps the pigs and chickens in, and the dogs out. Wire can also keep the dogs in, and the chickens and pigs out. Wire supports tomato plants and gives string beans something to climb on.

The 802.15.4 protocol rides on a radio wave. It does require external power or batteries to be radiated; 802.15.4 cannot be used as a conductor, a resistor, a thermometer, a tie wrap, or a fuse. By itself, 802.15.4 cannot keep animals in their place or provide a walking stick for tomatoes or beans. However, when it comes to transferring data, 802.15.4 radios are just as good as wire.

NOTHING IS FREE

When properly supported, an 802.15.4 radio can tell you how hot or how cold it is. An 802.15.4 radio with the right stuff can tell you if a fuse has blown or if the pigs are in the garden instead of in their pen. These super powers come with a price tag called energy. Usually, that energy is a product of a battery as AC mains power is normally not installed at the location of every tomato plant in a field. So, to make that 802.15.4 radio emulate a wire for a very long time, we must figure out how to conserve the energy provided by that battery.

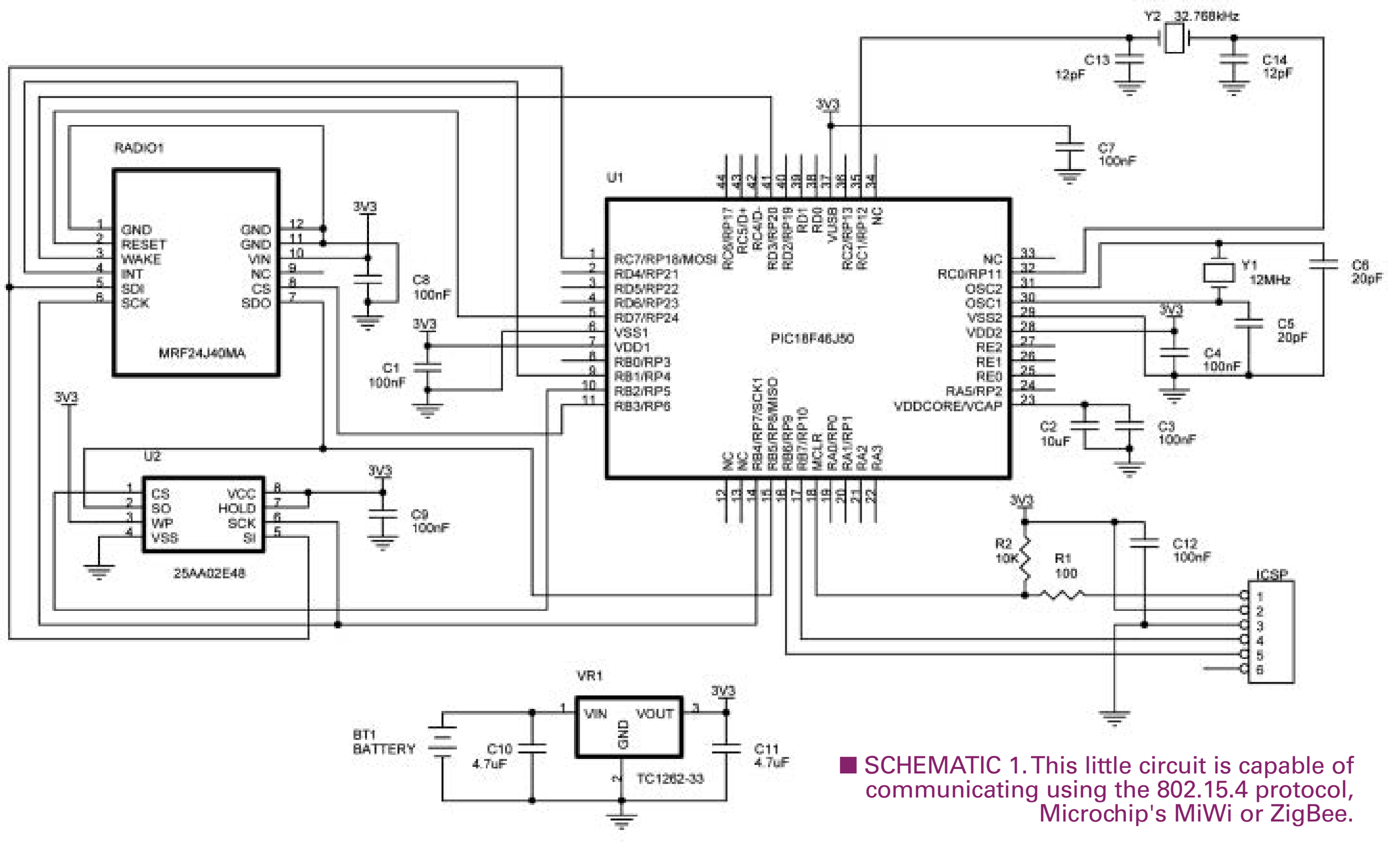
BEGINNING A LOW POWER RADIO DESIGN

The first and most important step in a low power radio design is to carefully choose the components. Our reference design is depicted in **Schematic 1**. As you can see (in **Schematic 1**), we are basing the design around a PIC18F46J50. The PIC18F46J50 is a member of the nanoWatt XLP (Extreme Low Power) family. Ridiculously low current consumption can be realized using the PIC18F46J50's sleep and deep sleep modes.

The 25AA02E48 EEPROM provides our low power radio node with a unique write protected 48-bit 802.15.4 radio address. The 25AA02E48 also allows us to store up to 192 bytes of data in its read/write EEPROM array. Like its host, the 25AA02E48 can be easily forced to conserve energy. A standby current consumption of 1.0 µA is obtained by simply driving the 25AA02E48's active-low CS line logically high. When powered by a 5.5 volt power supply, the worst case current consumption for the 25AA02E48 is 5.0 mA. The EEPROM draws a paltry 3.0 mA with a 2.5 volt power rail. We can count on a current consumption figure of approximately 4.0 mA with our 3.3 volt supply voltage.

The MRF24J40MA has the potential to consume the majority of the node's energy. We can curb the radio's energy appetite by forcing the MRF24J40MA to sleep. The MRF24J40MA is hungriest in transmit mode. Transmission burns 23 mA of current which is not much more than the receive current burn of 19 mA. As you would imagine, either of those sustained current consumption levels would quickly blow through battery packs. The MRF24J40MA is redeemed by requiring only 2 µA in sleep mode.

The voltage regulator also requires some operational energy. So, we'll go with a voltage regulator that is specifically designed to be used in battery-powered systems. The Microchip TC1262 is a 500 mA fixed output low dropout voltage regulator. By eliminating wasted


RADIO1
GND
RESET
WAKE
INT
SDI
SCK
GND
GND
VIN
NC
CS
SDO
MRF24J40MA
3V3
C8
100nF
C1
100nF
U1
RC7/RP18/MOSI
RD4/RP21
RD5/RP22
RD6/RP23
RD7/RP24
VSS1
VDD1
RB0/RP3
RB1/RP4
RB2/RP5
RB3/RP6
RC6/RP17
RC5/D+
RC4/D-
RD3/RP20
RD2/RP19
RD1
RD0
VUSB
RC2/RP13
RC1/RP12
NC
PIC18F46J50
NC
RC0/RP11
OSC2
OSC1
VSS2
VDD2
RE2
RE1
RE0
RA5/RP2
VDDCORE/VCAP
NC
NC
RB4/RP7/SCK1
RB5/RP8/MISO
RB6/RP9
RB7/RP10
MCLR
RA0/RP0
RA1/RP1
RA2
RA3
Y2 32.768kHz
C13
12pF
C14
12pF
C7
100nF
Y1
12MHz
C6
20pF
C5
20pF
C4
100nF
C2
10uF
C3
100nF
U2
CS
SO
WP
VSS
VCC
HOLD
SCK
SI
25AA02E48
C9
100nF
R2
10K
R1
100
C12
100nF
ICSP
VR1
VIN
VOUT
GND
TC1262-33
BT1
BATTERY
C10
4.7uF
C11
4.7uF

■ SCHEMATIC 1. This little circuit is capable of communicating using the 802.15.4 protocol, Microchip's MiWi or ZigBee.

ground current, the TC1262 adds a mere 80 µA to our power budget. The fruits of our design become physical in **Photo 1**.

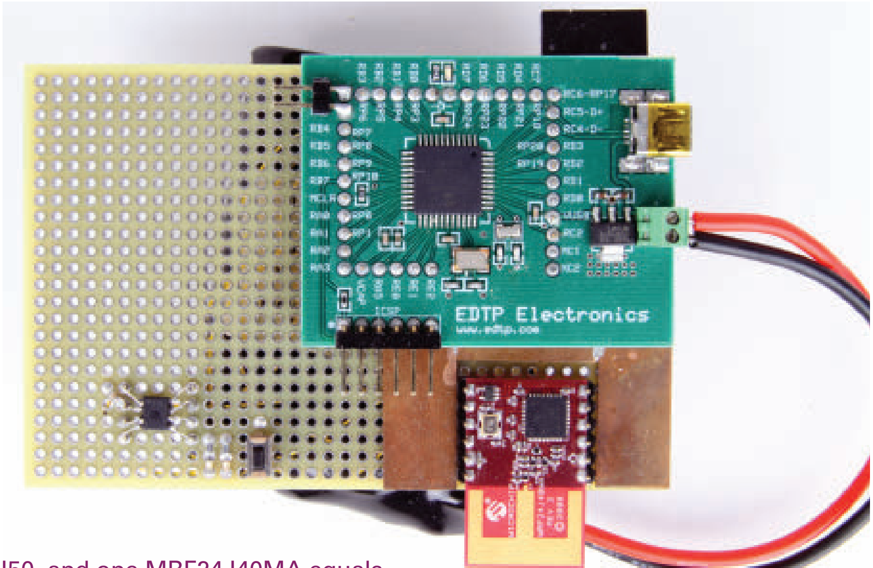
CLOCK CONSIDERATIONS

Running the PIC18F46J50 at full tilt boogie (48 MHz) pulls 33.7 mA. Turning off the PIC18F46J50's PLL and dividing the 12 MHz CPU clock by three reduces the current drain to 24.17 mA. Here's where you have to make a decision. Do you really want to save that few milliamps and take longer to send your message? Or, do you want to take less time to send the message and run the higher clock speed? Personally, I would choose to run as fast as necessary and keep my messages very short. In the long run, you'll use more energy in a shorter amount of time by taking the extra time to compute and send your data.

NIGHTY NIGHT

Regardless of the clock speed, our PIC18F46J50-based MRF24J40MA 802.15.4 node sleeps at 83.7 µA. The next thing to consider is how do we wake it up? The answer lies in the 32.768 kHz crystal and its supporting 12 pF capacitors.

The PIC is endowed with an internal RTCC which happens to be clocked by the 32.768 kHz crystal. The PIC's internal RTCC can do a bit more than just keep the time of day. It can also act as a CPU alarm clock. All of us know that alarm clocks are not all-knowing and need to be set. The same is true for the microcontroller's RTCC.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■ PHOTO 1. One 25AA02E48, one PIC18F46J50, and one MRF24J40MA equals one MiWi P2P node.

Setting the RTCC alarm begins with determining what period of time you want to pass before the alarm goes off. In most cases, waking the CPU every second or even every minute is detrimental to battery life. On the other hand, waking up after hours have passed may let the dogs into the chicken pen. With that, let's plan on waking the CPU in multiples of minutes that are less than one hour. To allow this to happen, we must set up the alarm mask bits to reveal only minutes and seconds. Here's the code:

```
INTCONbits.GIEH = 0;        //DISABLE INTERRUPTS
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 1;     //WRITE ENABLE RTCC
                            //REGISTERS
ALRMCFGbits.AMASK3 = 0;     //ALARM ONCE PER
                            //HOUR
ALRMCFGbits.AMASK2 = 1;
ALRMCFGbits.AMASK1 = 0;
ALRMCFGbits.AMASK0 = 1;
```

With the aforementioned alarm mask in place, we can set the alarm to go off anywhere between 00:00 and 59:59 (minutes:seconds). For instance, let's set the alarm to wake up the PIC every 20 minutes:

```
ALRMCFGbits.ALRMPTR1 = 1;   //WRITE ALARM
                            //BEGINNING AT DAY
ALRMCFGbits.ALRMPTR0 = 0;
ALRMVALL = 0x00;            //DAY
ALRMVALH = 0x00;            //MONTH
ALRMVALL = 0x00;            //HR
ALRMVALH = 0;               //Week Day
ALRMVALL = 0x00;            //SEC
ALRMVALH = 0x20;            //MIN
```

The alarm pointer (ALRMPTR<1:0>) value (0x02) decrements every time ALRMVALH is accessed until the ALRMPTR value reaches 0x00. Once that value is reached, it will remain the ALRMPTR value until the ALRMPTRx values are reset. As you can see, the ALRMPTR value of 0x00 exposes the minutes and seconds of the alarm time which we have set to 20:00.

The CPU is set to awaken once an hour, 20 minutes into the hour for one time only. That's not what we want to do. So, let's make sure this wake event happens continuously. We do that by setting the CHIME bit. While we're at it, we can go ahead and enable the alarms, as well:

```
ALRMCFGbits.CHIME = 1;      //ENABLE CONTINUOUS
                            //ALARMS
ALRMCFGbits.ALRMEN = 1;     //ENABLE ALARM
```

We are really not interested in using the RTCC as a wristwatch. However, to keep weird stuff from possibly happening with the RTCC, we'll feed it a valid time and date:

```
RTCCFGbits.RTCPTR1 = 1;     //WRITE INITIAL TIME
                            //AND DATE
RTCCFGbits.RTCPTR0 = 1;
RTCVALL = 0x12;             //YEAR
RTCVALH = 0;                //NULL
RTCVALL = 0x01;             //DAY
RTCVALH = 0x01;             //MONTH
RTCVALL = 0x23;             //HR
RTCVALH = 0;                //WD
RTCVALL = 0x59;             //SEC
RTCVALH = 0x59;             //MIN
```

January 1, 2012 was on a Sunday (Week Day 0). The time was set to 23:59:59 using the military BCD (Binary Coded Decimal) format which is required by the RTCC. We're done writing to the RTCC alarm and timekeeping registers. So, let's functionally enable and write disable the RTCC:

```
RTCCFGbits.RTCEN = 1;       //ENABLE RTCC
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 0;     //DISABLE RTCC
                            //REGISTER WRITES
INTCONbits.GIEH = 1;        //ENABLE INTERRUPTS
```

The PIC's RTCC uses interrupts to perform the CPU wakeup. It would be a good thing for us to enable the RTCC interrupts:

```
PIE3bits.RTCCIE = 1;
PIR3bits.RTCCIF = 0;
```

Wait, we're not done. The CPU will only be awakened every hour. To wake up the CPU every 20 minutes, we'll have to reset the time every 20 minutes. That's easy enough. The RTCC keeps time by incrementing the time of day values. All we have to do is reset the minutes and seconds to 00:00 every 20 minutes:

```
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 1;     //ENABLE RTCC
                            //REGISTER WRITES
ALRMCFGbits.ALRMEN = 0;     //DISABLE ALARM
RTCVALL = 0x00;             //RESET SEC
RTCVALH = 0x00;             //RESET MIN
ALRMCFGbits.ALRMEN = 1;     //ENABLE ALARM
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 0;     //DISABLE RTCC
                            //REGISTER WRITES
```

To keep from generating an extraneous alarm, we must disable the alarm function while we reset the minutes and seconds values. We're set on the wake-up side. Code is still needed to put the PIC18F46J50 and the MRF24J40MA to sleep. Tucking in the microcontroller can be performed with the help of a MiWi API cal and the PIC18F46J50's sleep command:

```
MiApp_TransceiverPowerState(POWER_STATE_SLEEP);
Sleep();
MiApp_TransceiverPowerState(POWER_STATE_WAKEUP);
PIR3bits.RTCCIF = 0;
```

As one would expect, the MRF24J40MA is forced into sleep mode before the PIC is fitted with its night cap. Twenty minutes later, the microcontroller awakens and nudges the MRF24J40MA. An operation is performed, a transmission is initiated, and everybody goes back to bed.

WHO ARE YOU

We can make up and assign a fictitious 64-bit

Extended Unique Identifier (EUI-64) in the MiWi *ConfigApp.h* file. However, it wouldn't be official. If you used the same *ConfigApp.h* information for another node, guess what? You would have two nodes with the same 802.15.4 address. So, instead we'll get the information necessary to form an official EUI-64 address from the 25AA02E48. The 25AA02E48 actually supplies 48 bits, which include the 24-bit OUI (Organizationally Unique Identifier) and the 24-bit EI (Extension Identifier).

The addition of 0xFFFE between the OUI and EI form the 64-bit address. The OUI consists of three bytes assigned to the manufacturer (0x00, 0x04, 0xA3) which, in this case, is Microchip. The EI is unique to every 25AA02E48. Our 25AA02E48's EI area contains 0x4D, 0xAF, and 0x94.

The 25AA02E48 is a 256-byte EEPROM that contains the 64-bit compatible address information in locations 0xFA through 0xFF. The EUI-48 information is write protected. Write protection begins at location 0xC0. That leaves 192 bytes of EEPROM available to the user (0x00:0xBF). The 25AA02E48 uses commands to read and write its EEPROM data space. To write to the 25AA02E48's EEPROM, we must first select the 25AA02E48 and set its write latch. Even though the EUI-48 area is write protected, we should take precautions to avoid accidentally writing there:

```
void WriteEE(BYTE addr, BYTE data)
{
    BYTE wdone;

       if(addr >= 0 && addr < 0xC0)
       {
         RF_EEnCS_TRIS = 0;
         RF_EEnCS = 0;      //SELECT EEPROM
         Nop();
         Nop();
         SPIPut(EEWREN);    //SEND WRITE ENABLE
                            //CMD
         RF_EEnCS = 1;      //SET WRITE LATCH
```

Once the 25AA02E48 is selected as the SPI slave and the write latch has been set, we can send its write command which is immediately followed by address and data information:

```
         RF_EEnCS = 0;
         Nop();
         Nop();
         SPIPut(EEWRITE);   //SEND WRITE CMD
         SPIPut(addr);      //SEND ADDRESS
         SPIPut(data);      //SEND DATA
         RF_EEnCS = 1;      //WRITE DATA
```

We can write up to 16 bytes of data behind a write command. The data is actually written when the active-low CS is driven from logically low to logically high.

As with most EEPROMs, the write process takes some time. So, to make sure we don't jump the gun, we'll check the 25AA02E48 WIP (Write In Progress) bit which is stationed in the STATUS register:

```
         RF_EEnCS = 0;      //CHECK WRITE IN
                            //PROGRESS FLAG
         Nop();
         Nop();
         SPIPut(EERDSR);
         do{
         wdone = SPIGet();
         }while(wdone & 0x01);     //WAIT FOR
                                   //WIP BIT TO
                                   //CLEAR
         RF_EEnCS = 1;
       }
}
```

Reading the user data area of the 25AA02E48 is a bit easier. We simply select it, make sure we're actually trying to read within the user data bounds, issue the read command followed by the address, and collect the data:

```
void ReadEE(BYTE addr)
{
       if(addr >= 0 && addr < 0xC0)
       {
         RF_EEnCS_TRIS = 0;
         RF_EEnCS = 0;
         Nop();
         Nop();
         SPIPut(EEREAD);    //Read Sequence to
                            //EEPROM
         SPIPut(addr);      //Data address Start
                            //byte
         EEdata = SPIGet(); //Read EE data
         RF_EEnCS = 1;
       }
}
```

Reading the EUI-48 area of the 25AA02E48 is identical to the user area read operation we just coded. We know that the EUI-48 area begins at address 0xFA. We also know that the first three bytes of a Microchip 25AA02E48 are 0x00, 0x04, and 0xA3:

```
void ReadMacAddress(void)
{
    RF_EEnCS_TRIS = 0;
    {
         BYTE    Address0, Address1, Address2;
         RF_EEnCS = 0;
         Nop();
         Nop();
         SPIPut(EEREAD);    //Read Sequence to
                            //EEPROM
         SPIPut(0xFA);      //MAC address Start
                            //byte
         Address0 = SPIGet();
         Address1 = SPIGet();
         Address2 = SPIGet();
         RF_EEnCS = 1;
```

Once we have verified that the 25AA02E48 is actually an 25AA02E48, we can build an EUI-64 by inserting the 0xFF/0xFE between the OUI and the EI data we will

SOURCES

Microchip
MiWi
ZENA
PIC18F46J50
MRF24J40MA
25AA02E48
Wireless Development Studio
www.microchip.com

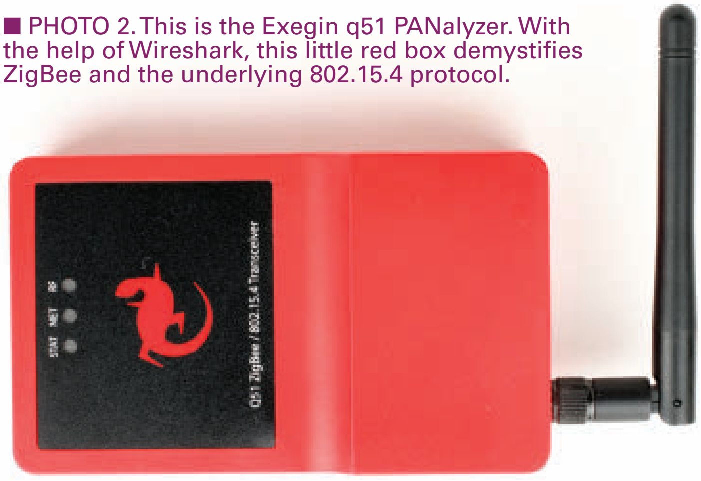
Exegin
q51 PANalyzer
www.exegin.com

Wireshark
www.wireshark.com

retrieve beginning at address 0xFD:

```
//Compare the value against Microchip's OUI
  if((Address0 == 0x00) && (Address1 == 0x04)
  && (Address2 == 0xA3))
  {
    RF_EEnCS = 0;
    Nop();
    Nop();
    SPIPut(EEREAD);
    SPIPut(0xFD);
    switch(MY_ADDRESS_LENGTH)
      {
        case 8: myLongAddress[7] = 0x00;
              //OUI
        case 7: myLongAddress[6] = 0x04;
        case 6: myLongAddress[5] = 0xA3;
        case 5: myLongAddress[4] = 0xFF;
              //64-bit STUFFING
        case 4: myLongAddress[3] = 0xFE;
        case 3: myLongAddress[2] = SPIGet();
              //EI
        case 2: myLongAddress[1] = SPIGet();
        case 1: myLongAddress[0] = SPIGet();
              break;
        default: break;
      }
  RF_EEnCS = 1;
}
```

■ PHOTO 2. This is the Exegin q51 PANalyzer. With the help of Wireshark, this little red box demystifies ZigBee and the underlying 802.15.4 protocol.



A very useful feature found within the MiWi protocol is the ability to identify a node with additional addressing information determined by the user. For instance, let's say you installed some nodes in your work shop. You could code the "shop1" node identifier using the EI information followed by the word "SHOP1:"

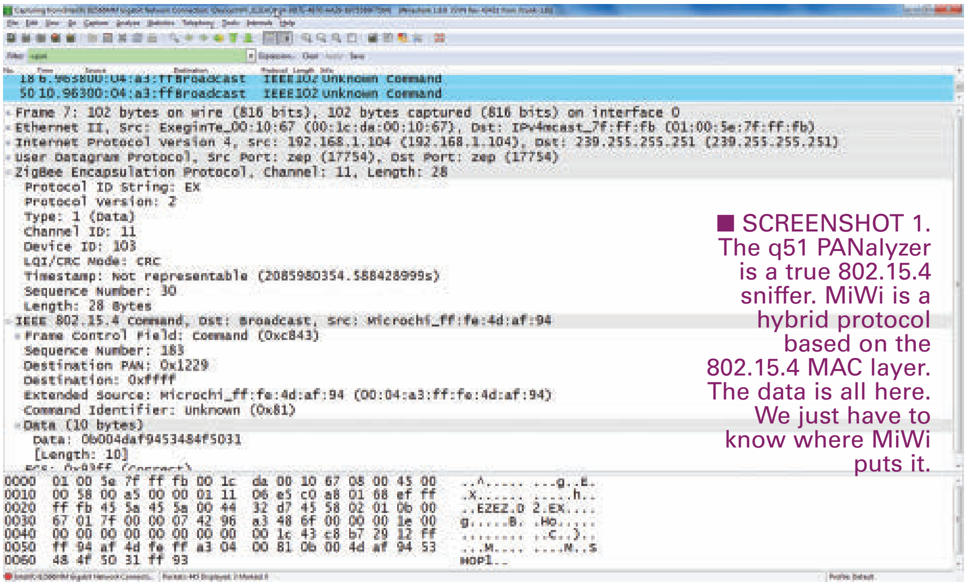
```
     }
     #if ADDITIONAL_NODE_ID_SIZE > 0
          AdditionalNodeID[0] = myLongAddress[2];
          AdditionalNodeID[1] = myLongAddress[1];
          AdditionalNodeID[2] = myLongAddress[0];
          AdditionalNodeID[3] = 'S';
          AdditionalNodeID[4] = 'H';
          AdditionalNodeID[5] = 'O';
          AdditionalNodeID[6] = 'P';
          AdditionalNodeID[7] = '1';
    #endif
}
```

The ADDITIONAL_NODE_ID_SIZE is entered in the MiWi *ConfigApp.h* file. The user-defined node ID information is transmitted in the network initialization exchange. So, you can code your application to only join with a specified node. For instance, the SHOP1 node should only talk to the LAWN1 node. Thus, you can align the EI of the node with its human name. Since you know the OUI and the 64-bit stuffing values, you can determine the EUI-64 address of SHOP1 and LAWN1, and have the ability to use them in your application.

I AM SPARTACUS

No, you are SHOP1. Let's explore **Screenshot 1** which is our SHOP1 node attempting to find a network partner. **Screenshot 1** is courtesy of the Exegin q51 PANalyzer shown in **Photo 2**. The q51 PANalyzer utilizes the Wireshark Network Sniffer to encapsulate 802.15.4 and ZigBee packets into Ethernet frames. The q51 PANalyzer allows a network analyst to monitor remote 802.15.4 and ZigBee networks via the Internet. As you can see in **Schematic 1**, the q51 PANalyzer works pretty dang good on local LANs, as well.

The IEEE 802.15.4 area of **Screenshot 1** is official 802.15.4 speak. You can see the PAN ID and our node's EUI-64 address. The Command Identifier is not a valid 802.15.4 command and is really a MiWi P2P connection request. The 0x81 also caused the data to skew. The first byte of the data (0x0B) is actually the channel number. The 0x00 byte that follows contains the bits that make up the MiWi node capacity field. The rest of the data field in **Screenshot 1** contains our EI



```
 18 6.96580O:04:a3:ffBroadcast   IEEE102 Unknown Command
 50 10.96300:04:a3:ffBroadcast   IEEE102 Unknown Command
Frame 7: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface 0
Ethernet II, Src: ExeginTe_00:10:67 (00:1c:da:00:10:67), Dst: IPv4mcast_7f:ff:fb (01:00:5e:7f:ff:fb)
Internet Protocol Version 4, Src: 192.168.1.104 (192.168.1.104), Dst: 239.255.255.251 (239.255.255.251)
User Datagram Protocol, Src Port: zep (17754), Dst Port: zep (17754)
ZigBee Encapsulation Protocol, Channel: 11, Length: 28
  Protocol ID String: EX
  Protocol Version: 2
  Type: 1 (Data)
  Channel ID: 11
  Device ID: 103
  LQI/CRC Mode: CRC
  Timestamp: Not representable (2085980354.588428999s)
  Sequence Number: 30
  Length: 28 Bytes
IEEE 802.15.4 Command, Dst: Broadcast, Src: Microchi_ff:fe:4d:af:94
  Frame Control Field: Command (0xc843)
  Sequence Number: 183
  Destination PAN: 0x1229
  Destination: 0xffff
  Extended Source: Microchi_ff:fe:4d:af:94 (00:04:a3:ff:fe:4d:af:94)
  Command Identifier: Unknown (0x81)
  Data (10 bytes)
    Data: 0b004daf9453484f5031
    [Length: 10]
0000  01 00 5e 7f ff fb 00 1c  da 00 10 67 08 00 45 00   ..^..... ...g..E.
0010  00 58 00 a5 00 00 01 11  06 e5 c0 a8 01 68 ef ff   .X...... .....h..
0020  ff fb 45 5a 45 5a 00 44  32 d7 45 58 02 01 0b 00   ..EZEZ.D 2.EX....
0030  67 01 7f 00 00 07 42 96  a3 48 6f 00 00 00 1e 00   g......B. .Ho.....
0040  00 00 00 00 00 00 00 00  00 1c 43 c8 b7 29 12 ff   ........ ..C..)..
0050  ff 94 af 4d fe ff a3 04  00 81 0b 00 4d af 94 53   ...M.... ....M..S
0060  48 4f 50 31 ff 93                                  HOP1..
```

■ SCREENSHOT 1. The q51 PANalyzer is a true 802.15.4 sniffer. MiWi is a hybrid protocol based on the 802.15.4 MAC layer. The data is all here. We just have to know where MiWi puts it.

■ PHOTO 3. This is the first cousin of the q51 PANalyzer. The ZENA can be used in 802.15.4, ZigBee, and MiWi networks.

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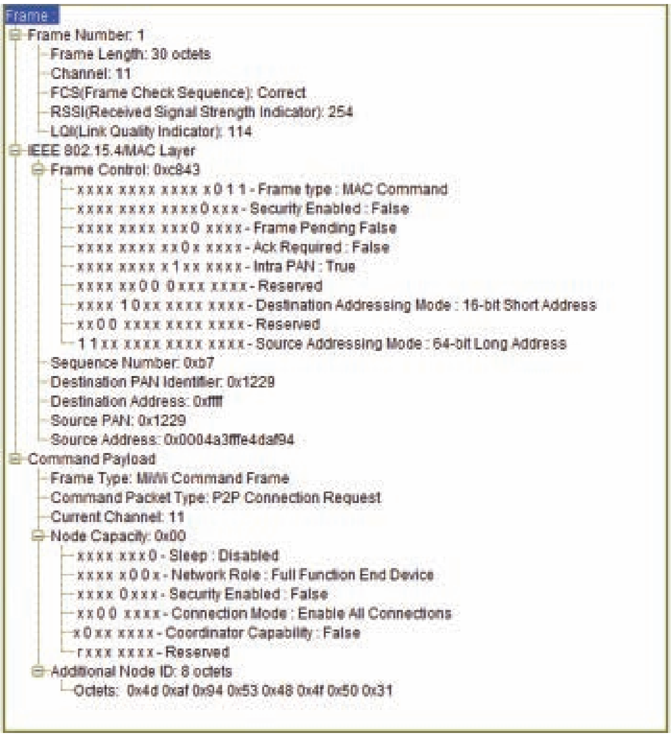
followed by SHOP1. You can use **Screenshot 2** to pick out the proprietary MiWi ways versus the official 802.15.4 protocol. **Screenshot 2** was generated by Microchip's Wireless Development Studio and the ZENA (**Photo 3**) which are tuned to sniff MiWi P2P packets.

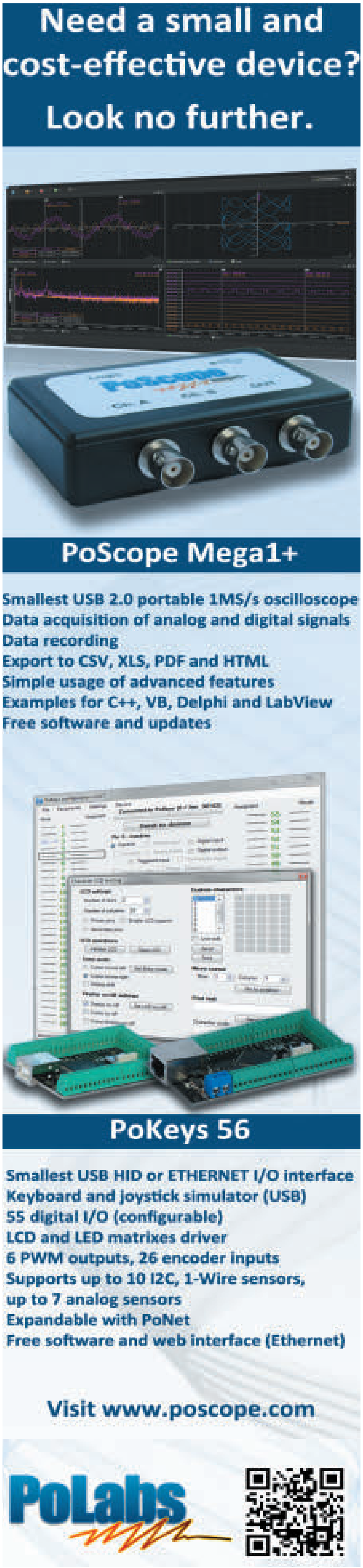
TWEAKS

Believe it or not, we can reduce sleep current consumption by replacing the TC1262 with a MCP1703A. The MCP1703A draws only 2 µA of operational current. Again, nothing is free. The MCP1703A can only supply a maximum of 250 mA to the load versus 500 mA provided by the TC1262. The MiWi P2P node you see in **Photo 1** has been sleeping on my bench now for about a week. Every 20 minutes, it wakes up and sends a couple of bytes. I figure I won't have to worry about charging its battery for quite some time. **NV**



```
Frame :
Frame Number: 1
    Frame Length: 30 octets
    Channel: 11
    FCS(Frame Check Sequence): Correct
    RSSI(Received Signal Strength Indicator): 254
    LQI(Link Quality Indicator): 114
IEEE 802.15.4/MAC Layer
    Frame Control: 0xc843
        xxxx xxxx xxxx x011 - Frame type : MAC Command
        xxxx xxxx xxxx0xxx - Security Enabled : False
        xxxx xxxx xxx0 xxxx - Frame Pending False
        xxxx xxxx xx0x xxxx - Ack Required : False
        xxxx xxxx x1xx xxxx - Intra PAN : True
        xxxx xx00 0xxx xxxx - Reserved
        xxxx 10xx xxxx xxxx - Destination Addressing Mode : 16-bit Short Address
        xx00 xxxx xxxx xxxx - Reserved
        11xx xxxx xxxx xxxx - Source Addressing Mode : 64-bit Long Address
    Sequence Number: 0xb7
    Destination PAN Identifier: 0x1229
    Destination Address: 0xffff
    Source PAN: 0x1229
    Source Address: 0x0004a3fffe4daf94
Command Payload
    Frame Type: MiWi Command Frame
    Command Packet Type: P2P Connection Request
    Current Channel: 11
    Node Capacity: 0x00
        xxxx xxx0 - Sleep : Disabled
        xxxx x00x - Network Role : Full Function End Device
        xxxx 0xxx - Security Enabled : False
        xx00 xxxx - Connection Mode : Enable All Connections
       x0xx xxxx - Coordinator Capability : False
        rxxx xxxx - Reserved
    Additional Node ID: 8 octets
       Octets:  0x4d 0xaf 0x94 0x53 0x48 0x4f 0x50 0x31
```

SCREENSHOT 2. Here's the Microchip Wireless Development Studio interpretation of the captured MiWi P2P data shown in Screenshot 1. Using this as a template, it's easy to see where MiWi strays from the 802.15.4 rules.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September 2012

Popular Kits for Electronics Enthusiasts

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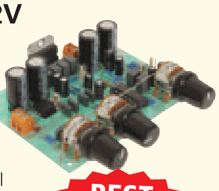
High Performance 12V Stereo Amplifier Kit

Cat. KC-5495



An ideal project for anyone wanting a compact and portable stereo amp where 12V power is available. No mains voltages, so it's safe as a school project or as a beginner's first amp. Performance is an excellent with 20WRMS per channel at 14.4V into 4 ohms with THD of less than 0.03%. Shortform kit only.

BEST SELLER!

$32.75*

- 12VDC
- Recommended heatsink **(use HH-8570 $3.75)**
- PCB: 95 x 78mm

Studio 350 - High Power Amplifier

Cat. KC-5372

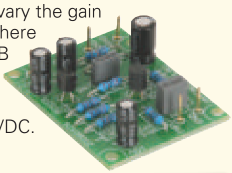
Delivers a whopping 350WRMS into 4 ohms or 200WRMS into 8 ohms. It offers real grunt using a high power MJ21193/4 transistor and is super quiet with a very low signal to noise ratio and harmonic distortion. This kit is supplied in short form with PCB and electronic components. Kit requires heatsink and (+/-) 70V power supply as described in instructions. See website for more specifications.

$126.00*

"Pre-Champ" Versatile Preamplifier

Cat. KC-5166

This tiny preamp was specifically designed to be used with the 'Champ' amplifier KC-5152 below. Unless you have a signal of sufficient amplitude the 'Champ' will not produce its maximum power output. The 'Pre-Champ' is the answer with a gain in excess of 40dB, which is more than enough for most applications. You can vary the gain by changing a resistor and there is even provision on the PCB for an electret microphone. Use **AM-4010 $1.50**.



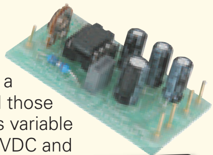
- Power requirement: 6-12VDC.
- Kit includes PCB and electronic components
- Can be battery powered
- PCB: 46 x 36 mm

$6.50*

"The Champ" Audio Amplifier

Cat. KC-5152

This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9V supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9V battery, allowing it to fit into the tightest of spaces.



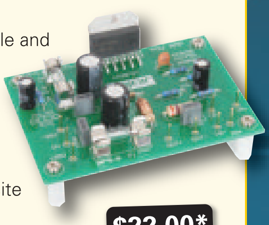
$6.00*

- PCB and electronic components included
- PCB: 46 x 26 mm

50 Watt Amplifier Module

Cat. KC-5150

Uses a single chip module and provides 50WRMS @ 8 ohms with very low distortion. PC board and electronic components supplied. Requires heatsink and (+/-) 35V power supply. See website for full specs.



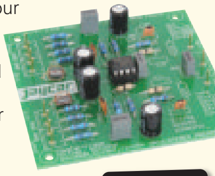
$22.00*

- PCB: 84 x 58 mm
- Heatsink to suit **HH-8590 $9.50**

Universal Stereo Preamplifier

Cat. KC-5159

Based around the low noise LM833 dual op-amp IC, this preamp is designed for use with a magnetic cartridge, cassette deck or dynamic microphone. The performance of this design is far better than most preamps in many stereo amplifiers, making it a worthy replacement if your current preamp falls short of expectation. It features RIAA/IEC equalisation, and is supplied with all components to build either the phono, tape or microphone version.



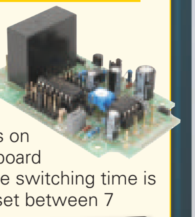
- +/- 15VDC
- PCB: 80 x 78 mm

$12.50*

Timer Kits

The 'Flexitimer'

Cat. KA-1732



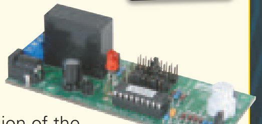
Now in it's 3rd revision by Jaycar, the flexitimer remains one of our most versatile short form projects. The flexitimer runs on 12-15V DC and switches the on-board relay once or repeatedly when the switching time is reached. Switching time can be set between 7 seconds and 2 hours in fixed steps.

$14.50*

- PCB size: 74 x 47mm

Low Cost Programmable Interval Timer

Cat. KC-5464



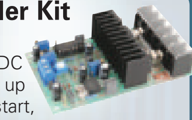
Here's an updated version of the very popular low cost 12VDC electronic timer. It is link programmed for either a single ON, or continuous ON/OFF cycling for up to 48 on/off time periods. Selectable periods are from 1 to 80 seconds, minutes, or hours and it can be restarted at any time. Kit includes PCB, program micro and electronic components.

$25.25*

- PCB: 102 x 42mm

Motor Speed Controller Kit

Cat. KC-5502



Control the speed of 12 or 24VDC motors from zero to full power, up to 20A. Features optional soft start, adjustable pulse frequency to reduce motor noise, and low battery protection. The speed is set using the onboard trimpot, or by using an external potentiometer (available separately, use **RP-3510 $1.50**).

$29.00*

- Supplied with PCB & all onboard electronic components
- PCB: 106 x 60mm

Crazy Cricket & Freaky Frog Kit

Cat. KC-5510

A fun first project for a budding electronics enthusiast. Designed to imitate the chirping noise of a cricket or gentle croaking of a frog (alternates at power up), while keeping its location secret to annoy other family members. It activates in darkness and stops when disturbed by light. Kit supplied with PCB, pre-programmed micro battery and electronic components.

- PCB: 30 x 65mm

$14.50*

Popular Kits

Jacob's Ladder High Voltage Display Kit MK2

Cat. KC-5445

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display. Kit includes PCB, pre-cut wire/ladder and electronic components.

$31.00*

- 12V car battery, 7Ah SLA or > 5A DC power supply required
- PCB: 170 x 76mm

THOUSANDS SOLD!

Theremin Synthesizer Kit MkII

Cat. KC-5475

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna. It's now easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.

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Jaycar
THEREMIN

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- PCB: 85 x 145 mm

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SPIN ZONE

ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

SHOW TIME!

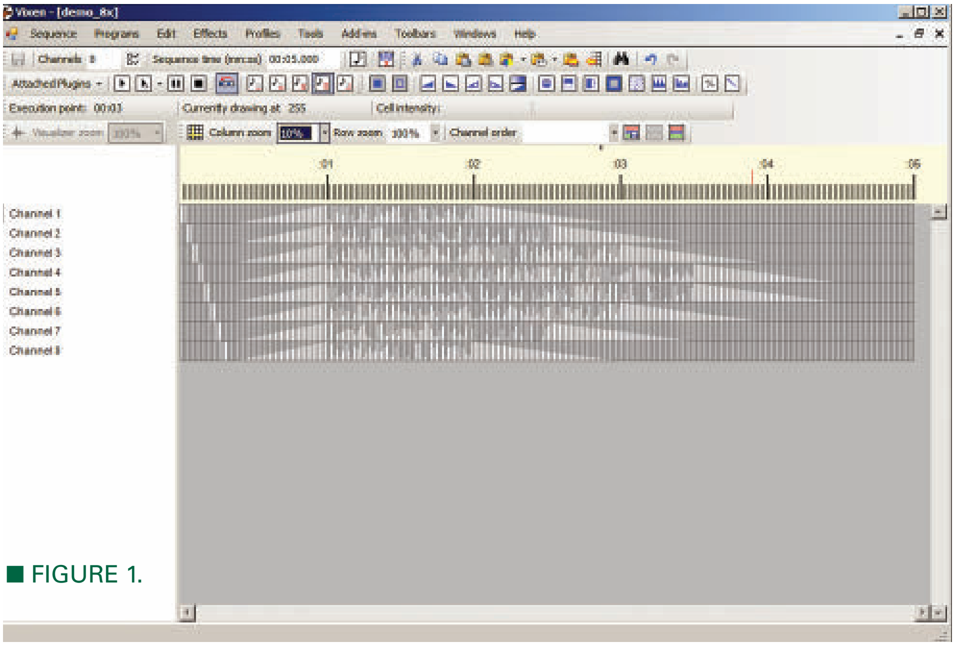
Those that know me well know that this is my favorite time of year. Halloween is right around the corner and that's followed up by the Christmas "season" — a couple months where prop displays flourish and indoor/outdoor decorators feverishly work to eclipse their creations of years past. I love this season. A lot of my electronics work involves small-scale show control and now — thanks to my favorite show control software — things are even better.

About five years ago, I came across a neat piece of freeware called Vixen that was created by a really nice guy named K.C. Oaks. The original intent behind Vixen was to allow DIY Christmas lighting enthusiasts to have a free platform on which to create complex shows. While playing with Vixen, it dawned on me – *as it would any hacker worth his/her salt* – that if I could control lights with Vixen I could control just about anything else; it's a matter of thinking in terms of channel level(s) meaning something other than light intensity.

In addition to being an outright nice guy, K.C. is amazingly responsive to customer requests for new features and software modules used by Vixen. To his credit, the program design is highly modular which allows him (and others with .NET programming skills) to make additions without upsetting the entire apple cart.

I recently asked K.C. for a new add-in module that will export the show data to a file in binary format. This keeps the files as small as possible. By adding a microSD socket and the FSRW object to a Propeller project, we can play that file without the need for a computer. This is big! We can use Vixen to create complex sequences, save them to a file, and then have the Propeller chip play them back.

As I mentioned earlier, I do a lot of small-scale show control programming. There are times when programming complex sequences in code can become extremely tedious. Developing a sequence in Vixen that can play through our hardware while we're developing is important – so we'll start there. The second step will be to create a program which can open and read a file exported by Vixen – completely untethered from the PC. We get the best of both worlds: Use a graphical interface to "paint" our sequences and play them live; once satisfied, export them and play them right off an SD card.



Vixen - [demo_8x]

Channels: 8

Sequence time (mm:ss): 00:05.000

Execution point: 00:03

Currently drawing at: 255

Cell intensity:

Column zoom 10%

Row zoom 100%

Channel order

■ FIGURE 1.

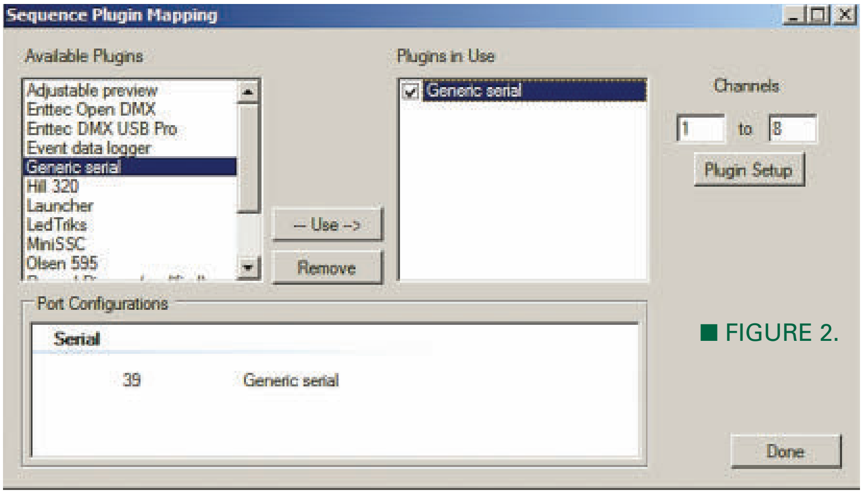
GETTING STARTED WITH VIXEN

You'll need to pop over to **www.vixenlights.com** to download the latest version of Vixen. You'll want to download the driver updates K.C. has provided for me at the article link (you can also find these in the Vixen section of the EFX-TEK support forums).

Just a note on replacing DLLs used by Vixen: If you don't want to overwrite a DLL used by Vixen, you can rename it but you must rename the extension. This is important! All

DLLs in certain folders are automatically loaded when the program starts, and to have duplicates — even if you have changed the name — can create conflicts. By changing the extension (I use .DXX), the old file will be ignored by Vixen and there won't be any problems.

Figure 1 is the Vixen 2.1.x.x interface with the data for a very simple eight-channel sequence. For testing shows on our hardware, we will use the generic serial output driver and pump that right into the Propeller's programming port. You can get to this driver by clicking on the *Attached Plugins* toolbar button. This will cause the display of the dialog box in **Figure 2**. When we first create a sequence, there will be no attached plug-ins. Find **Generic serial** in the *Available Plugins* list, click on it, and then click the **Use** button. Now, click on it in the *Plugins In Use* list, set the channels used, and then click on **Plugin Setup** to set the COM port and baud rate. I use 115.2K baud. The serial dialog box allows for text headers and footers — leave these blank (see **Figure 3**). If you spend about an hour with the tool buttons, you can master creating sequences with Vixen. For my use, I like to set the visual display to look like ramps instead of density graphs, and I prefer to display values as values (0 to 255) instead of percents (0 to 100). Play. Yes, I said play. Drag-select a group of cells and click the ramp on or ramp off. See how easy that was? There are separate buttons for partial ramps and for lighting effects like randomizing, sparkling, and shimmering.



Available Plugins:
Adjustable preview
Enttec Open DMX
Enttec DMX USB Pro
Event data logger
Generic serial
Hill 320
Launcher
LedTriks
MiniSSC
Olsen 595

Plugins in Use: ☑ Generic serial

Channels: 1 to 8

Serial	
39	Generic serial

■ FIGURE 2.

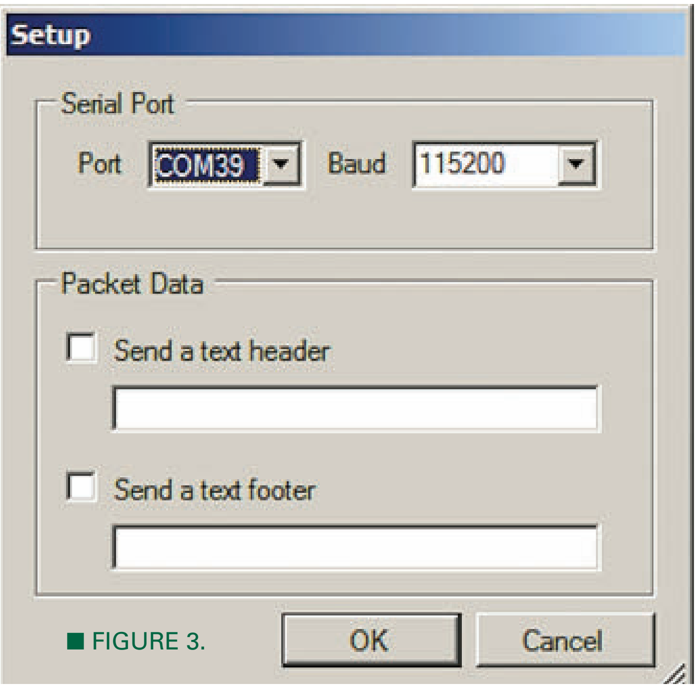
Let's look at the output on a Propeller board, shall we? I have a version of code that will run on a QuickStart board (available at your corner RadioShack), a demo board, or on any other board that you can connect eight LEDs to (use P16..P23 for the LED outputs). The serial connection from Vixen to the Propeller will be through the Propeller's programming port.

The code on the Propeller side is very easy. We'll load up a serial object and a PWM controller for LEDs (I covered that last year), and at the core, have this code:

```
pub main | level, ch

  serial.start(RX1, TX1, %0000, BAUD)
  leds.start(8, LED1)

  pause(10)
  serial.rxflush

  repeat
    repeat
      level := serial.rxtime(3)
    until (level < 0)

    repeat
      level := serial.rxcheck
    until (level => 0)
    leds.set(0, level)

    repeat ch from 1 to CHANNELS-1
      level := serial.rxtime(1)
      leds.set(ch, level)
```

Yeah, that's it, as long as the target output is a set of LEDs (more on this later). At the top, we start the serial and PWM objects, allow things to settle, clear any trash from the serial input buffer, and then drop into the main loop. Inside the big loop are three smaller loops. The first waits until the serial line is idle for at least three milliseconds; this is the shortest allowable gap between channel packets. I borrowed this strategy from the MODBUS RTU communications protocol: Frames are transmitted as a contiguous group with the space between frames used for synchronization.

The second loop waits until the first channel byte



Port: COM39 Baud: 115200

☐ Send a text header

☐ Send a text footer

■ FIGURE 3.

arrives. By doing this in a loop with **.rxcheck**, we could break out if we wanted. In this case, we're just waiting for a valid channel value (0..255). After the first channel arrives, we drop into the final loop that is set up to receive the rest of the channel levels. We're using a timeout again so that we can detect and deal with a broken stream. Of course, we have to ensure that the CHANNELS constant in the code matches what Vixen is transmitting for this to work. With the raw data stream emitted from Vixen, there is no way for the Propeller to detect the number of channels per each frame; we have to set that value.

I will admit to being easily entertained, and I have used this simple code to learn how to manipulate Vixen shows. I suggest you do the same thing. Download the program called *qs_vixen_streamer.spin* into a QuickStart or demo board and play with it. I think it's far easier to learn when one is having fun versus being under the stress of a deadline. Trust me when I tell you that "painting" a show in Vixen and then watching it play out on a QuickStart board can be very addicting. You may forget to check your Facebook page!

HACKING HALLOWEEN — AND CHRISTMAS, TOO!

Vixen is a light show controller but as with any computer program, Vixen is simply manipulating numbers; we assign meaning to those numbers. The output is essentially analog across a given range and yet for some devices, we'll convert the Vixen channel level to a pure digital state. For most applications, we'll want a 50-50 split:

```
  outa[ch] := level >> 7
```

Unfortunately, Spin doesn't have dot notation for bits so we have to get shifty. By shifting *level* right by seven bits, we are — in fact — moving bit 7 of *level* to the output. Bit 7 has a value of 128, so when the channel value is at or past the midpoint the channel will be on. Easy-peasy.

If we want something other than 50-50, we can use a comparison:

```
  outa[ch] := (level => THRESHOLD)
```

This will set the channel output to 1 (on) whenever the comparison evaluates as true.

Let's go the other way and extend things. In the animatronics world, model airplane servos are often used for motion. Is it possible to control servos from Vixen? You betcha; as ever, it's a small matter of programming.

A 180 degree servo expects a pulse from 600 to 2,400 microseconds to set its position (or speed if it has been modified for continuous rotation). To control a servo from Vixen, we need to scale the values created by Vixen (0 to 255) to a position/speed value (600 to 2,400).

This is the simple method I use for scaling a zero-based value to another range:

```
pub scale(raw, range, minout, maxout)

  raw := 0 #> raw <# range

  return ((raw * (maxout - minout)) {
  } / range) + minout
```

You probably recognize this as a standard *mx* + *b* equation. It accepts a 0..n value defined by range and converts to a new range defined by *minout* and *maxout*. To convert the 0 to 255 values from Vixen to a 180 degree servo pulse width, we'd do something like this:

```
  pwidth := scale(pos, 255, 600, 2400)
```

For a 90 degree servo, the output values would be 1,000 and 2,000. The value in *pwidth* would be passed to the servo control object for the channel running a servo. (See my September '11 column for details on controlling servos with the Propeller.)

In my July '11 column, I demonstrated simple motor control with the Propeller using a small H-bridge. To keep things easy, my code expects speed in percent ranging from -100 for full speed reverse to 100 for full speed forward. The scale method works with negatives too, which means we can do this:

```
  speed := scale(speed, 255, -100, 100)
```

The modified speed value can now be passed to the motor control object methods.

The point here is to think beyond the box. So, we get 0 to 255 from Vixen. It's just a number and with some imagination, we can turn that into anything we like. Heck, we could even monitor a channel value and have that trigger a process that runs in a separate cog; yes, we could use a stream value as a trigger. A friend of mine is an engineer for a rodent-friendly amusement park and often uses this strategy to trigger a prop based on a specific channel value in a DMX stream.

Lest you think that I think that I'm very clever, rest assured that I don't. Unless liberating good ideas from where they've succeeded before is clever. The next time you're at a big show or out in a club, take a few moments to watch the lighting. It's not just a matter of brightness, we see color change, movement, and special effects in certain fixtures. Theaters and clubs use DMX show control and as you're probably aware, DMX values are 0 to 255 on each channel. What we choose to do with those values is up to us.

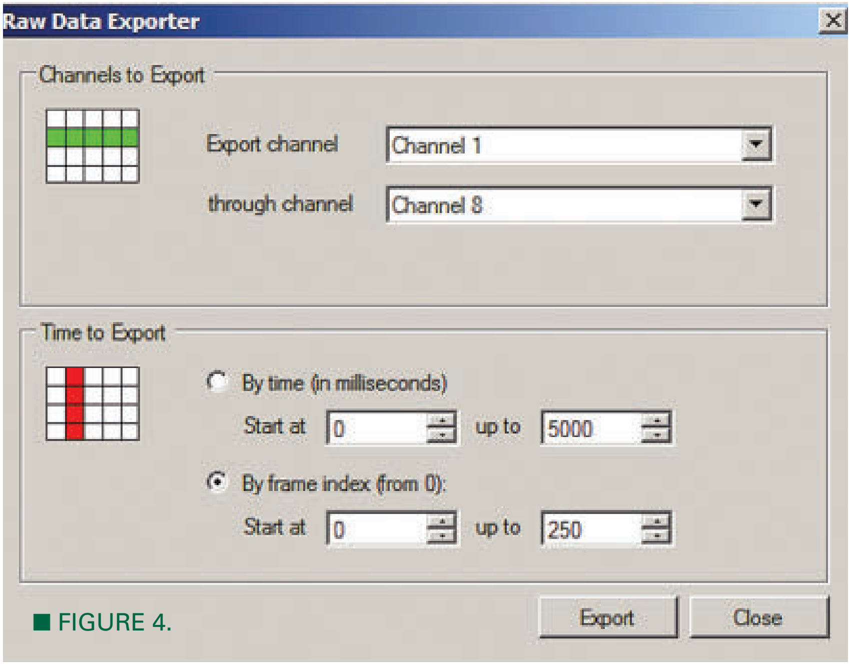
STAND-ALONE PLAYBACK

Generating a sequence on a PC is really cool, but when we want to deploy a number of individual decorations around a display, requiring the PC becomes impractical. Thanks to K.C., that's no longer a problem. The new **Raw Data Exporter** add-in allows us to export the show data to a binary file. Using the FSRW object (found in ObEx), we can open, read, and play back this file — just as if it was being streamed from a PC.

Again, I will admit that this is not an original idea; I "liberated" it. In June, I was asked to write a Propeller program that could play files exported from VSA — another show control program (that is targeted toward servo animatronics). VSA has a binary export function that will provide each channel as a 32-bit long that is directly compatible with the Propeller.

My problem with the VSA export is that the file only holds the channel data; we have no way of discerning from the binary file the number of channels in the project or the timing between frames. This means that the program playing the VSA file needs to know how many channels are in each frame and the frame-to-frame timing at which the show was created. Bogus ...

When K.C. and I talked, we decided to provide more information from Vixen. At the beginning of the Vixen export file, there are three 16-bit values that define the number of channels, the event timing (in milliseconds), and the number of frames exported. After this header is the channel data; one byte per channel. The number of frames exported will usually be the show length, but the export dialog allows us to change that. **Figure 4** shows the export dialog.


Raw Data Exporter

Channels to Export

Export channel: Channel 1

through channel: Channel 8

Time to Export

○ By time (in milliseconds)

Start at 0 up to 5000

● By frame index (from 0):

Start at 0 up to 250

■ FIGURE 4.

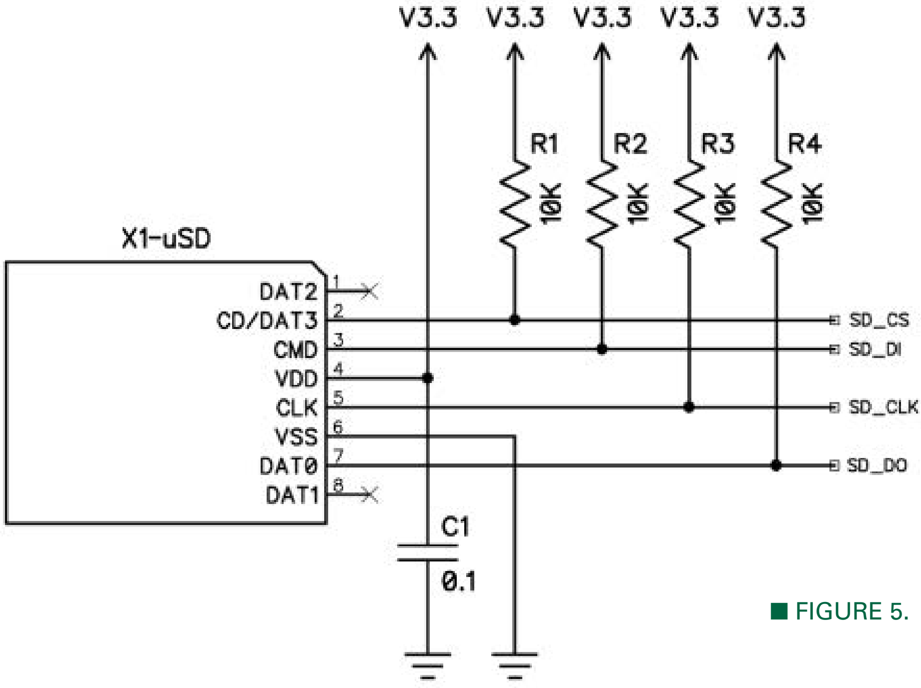
THE CARD GAME

In order to read files from an SD card, we have to connect one to the Propeller. This is pretty easy, requiring just four I/O pins (see **Figure 5**). When possible, I try to order the pins: DO, CLK, DI, and CS so that I can use the **.mount** method in FSRW. If you don't have four contiguous pins, that's not a problem; another method — **.mount_explicit** — allows you to specify the connections in any order. So, let's get connected, shall we?

The first thing to do is mount the SD card to establish communications with it:

```
pub mount_sd | check

  check := \sd.mount(SD_DO)

  if (check => 0)
    mounted := true
  else
    mounted := false

  return mounted
```

What you'll immediately notice is the backslash character ahead of the call. This is an abort trap that allows the program to return to the trap point in the event of a problem. In most cases, a method will simply end or may return a value. Another means of terminating a method is with **abort**. In this situation, however, the call stack will be popped all the way back to the abort trap



■ FIGURE 5.

JON “JONNYMAC” WILLIAMS
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point. This prevents intermediate returns on the stack from running code with bad values. The methods we'll use in FSRW will escape with abort codes that are negative. In the above shell method, we allow the abort to be trapped and check its value. A global variable called *mounted* is set for use by other file methods.

To read a file, we have to open it; in FSRW, the **.popen** method is used. I encapsulate that in the following method which expects a pointer to the file name (z-string), and the mode in which the file is to be opened (character):

```
pub open_file(spntr, mode) | check

  if (mounted)
    check := \sd.popen(spntr, mode)
    if (check => 0)
      if ((mode == “r”) or (mode == “R”))
        \sd.seek(0)
      return true
    else
      return false
  else
    return false
```

This may look a little more involved than absolutely necessary but I've found that when opening a file for reading, using **.seek** at the beginning of the file seems to improve performance of the first read from that file.

We've mounted the SD card and opened the file; it's time to start reading. For my Vixen file reader, I have the following variables:

```
var

  long  mounted

  word  chcount
  word  eventms
  word  frames

  byte  framebuf[MAX_CHANNELS]
```

Remember that the compiler will sort variables by size; longs, words, then bytes — it's helpful just to define them that way, especially as in this case where we want to treat the *chcount*, *eventms*, and *frames* variables as a group. Direct reads in FSRW are to an array of bytes. To retrieve the Vixen file header, we use **readbuf** which encapsulates FSRW's **.pread** method:

```
  readbuf(@chcount, 6)
```

Note that we're passing the address of *chcount* and instructing FSRW to read six bytes (three words is six bytes). This works because Vixen outputs the words “Little Endian” the same way they are stored in the hub RAM. Here's the shell method for reading a block of bytes:

```
pub readbuf(bpntr, n) | check

  check := \sd.pread(bpntr, n)
  if (check == n)
    return true
  else
    return false
```

This converts a good read to **true** and a problem to **false**, simplifying the rest of the code. Once we know the number of channels, the frame timing, and the number of frames in the file, a simple loop can be used to play the file. Here's a section of my final streamer/player program:

```
  t := cnt
  repeat frames
    if (readbuf(@framebuf, chcount))
      repeat ch from 0 to chcount-1
        update_channel(ch, framebuf[ch])
      waitcnt(t += (MS_001 * eventms))
      toggle(G_LED)
    else
      quit
```

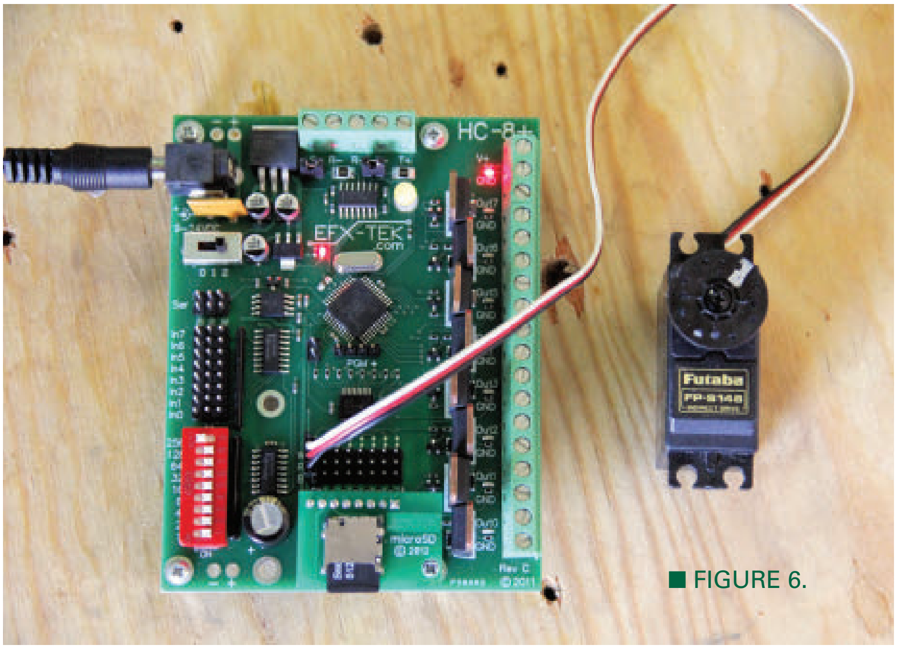
After reading the header, we can read one frame of channel data and send it to the outputs. In the above code, I'm using a routine called **update_channel** that converts the data for different kinds of outputs (my final program supports servos and dimmer channels). The loop will continue for the number of frames indicated in the header, or until the end of the file is located (this would indicate a problem with the file).

PUTTING IT ALL TOGETHER

My favorite piece of hardware for props and decorations is the EFX-TEK HC-8+ controller (**Figure 6**).

Yes, I had a hand in creating it, but that doesn't generate automatic bias (I've created a lot of products in the last 30 years that I don't get very excited about). The HC-8+ was designed to support the kinds of things I, my friends, and my customers have been wanting to do for a long time.

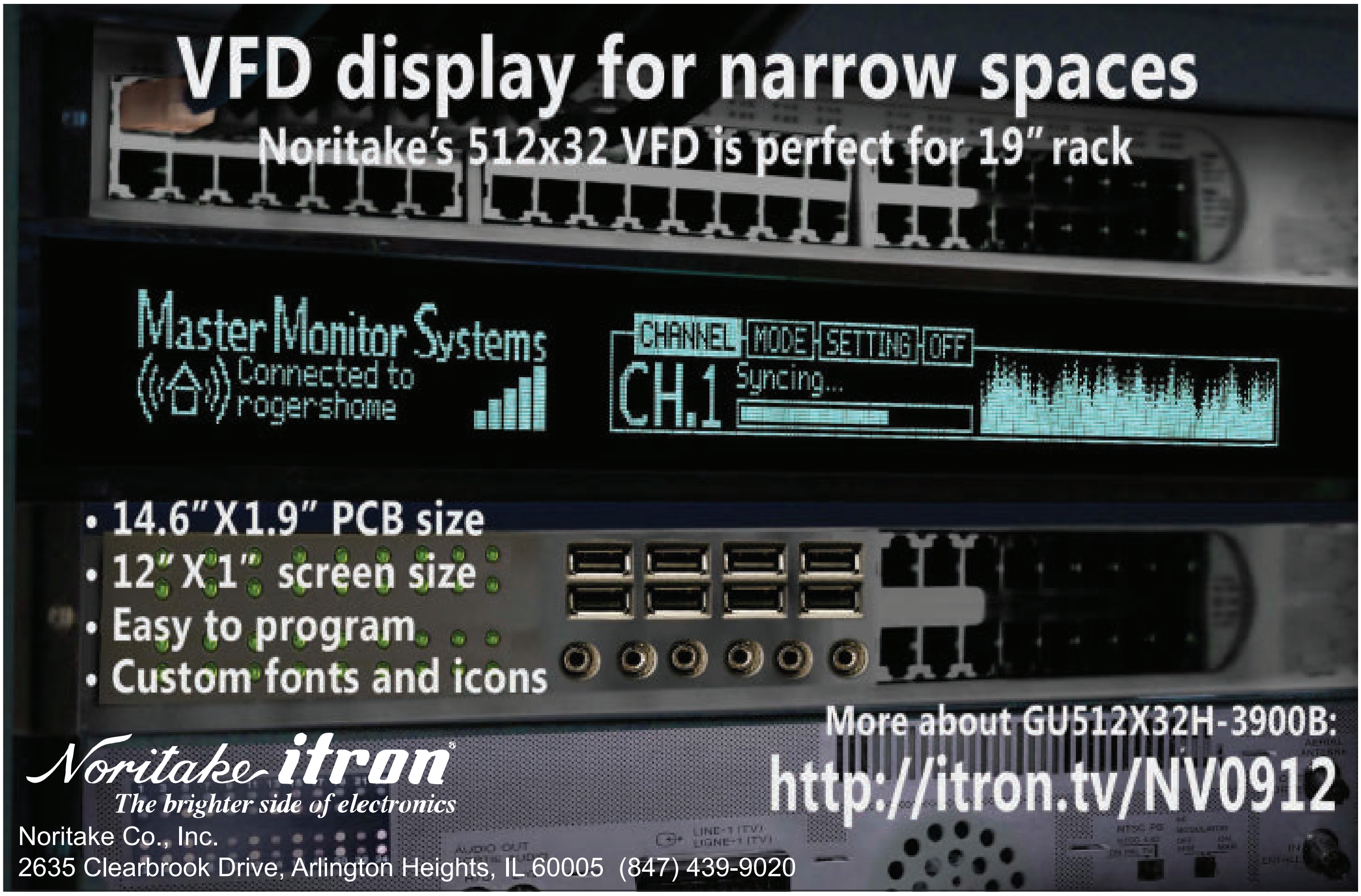
In addition to eight high current outputs (with built-in LEDs that show channel status), eight TTL inputs, and a full-duplex RS-485 port, it has an option for adding a microSD socket which means we can create a unified program to play live Vixen data, or from a show file on the microSD card.



■ FIGURE 6.

The output drive to the high current transistors is fed through servo-compatible three-pin headers so the board can — with a bit of software — run servos and high current dimmers at the same time. This is why it's my favorite for small prop and animatronics control. Have a look at the program, *jm_hc-8+_vixen_player.spin*. It uses all of the code we've discussed here in a unified program, and even includes a few extra goodies that we didn't have time to cover.

Okay, Halloween is just down the road a few weeks; it's time to start hacking your favorite props and giving them new life with a Propeller-powered Vixen show player! Until next time, keep spinning and winning with the Propeller. **NV**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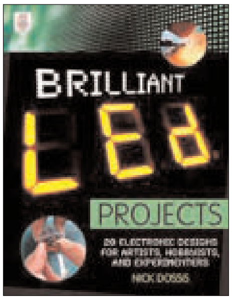

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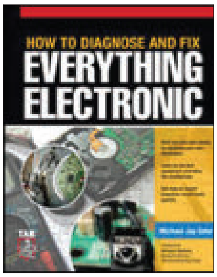

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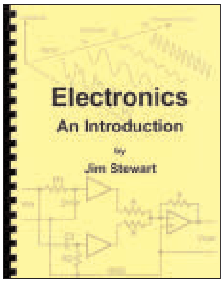

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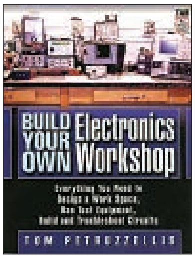

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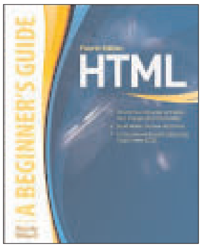

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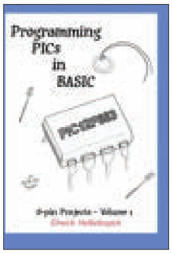

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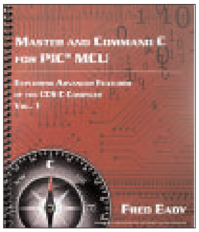

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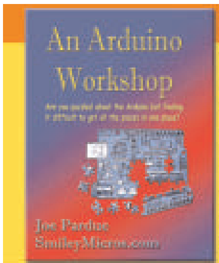

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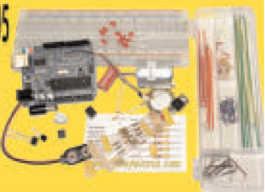

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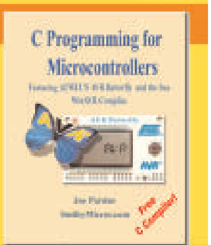

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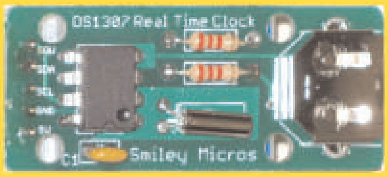

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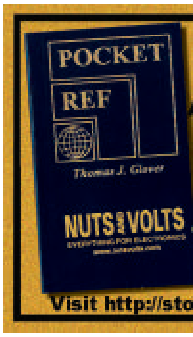

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PROJECTS

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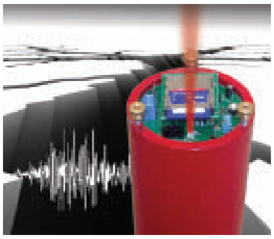
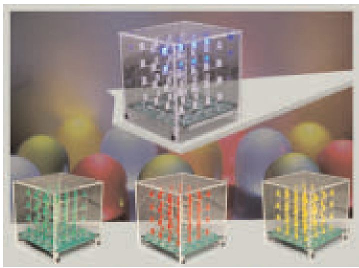


As seen in the May 2012 issue. Now you can record your own shaking, rattling, and rolling.

The Poor Man's Seismograph is a great project /device to record any movement in an area where you normally shouldn't have any. The kit includes everything needed to build the seismograph. All you need is your PC, SD card, and to download the free software to view the seismic event graph.

Subscriber's Price **$79.95**
Non-Subscriber's Price **$84.95**

3D LED Cube Kit



This kit shows you how to build a really cool 3D cube with a 4 x 4 x 4 monochromatic LED matrix which has a total of 64 LEDs. The preprogrammed microcontroller that includes 29 patterns that will automatically play with a runtime of approximately 6-1/2 minutes.
Colors available: Green, Red, Yellow & Blue

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MARVEL
BATTERY

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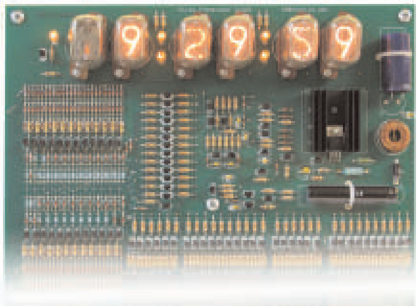
Neon Transistor Clock Kit



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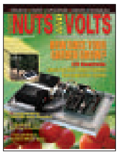
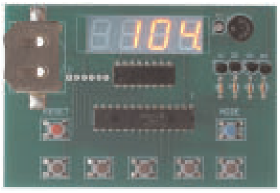
Sorting Counter Kit



As seen in the July 2011 issue.



Sorting counters have many uses — keeping score, counting parts, counting people — it is just a handy gadget to have around. This is a very simple project for those who want to learn to solder or are interested in using microprocessors and how they function. No special tools are needed, just a small tip soldering iron. It has no box as it stands alone, therefore there is no drilling.

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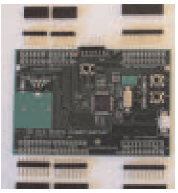

The 32-Bit Micro Experimenter is the fastest way to learn 32-bit microcontrollers.

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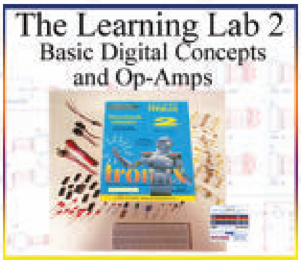

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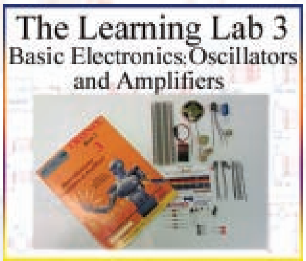

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The labs in this series — from GSS Tech Ed — show simple and interesting experiments and lessons, all done on a solderless circuit board.

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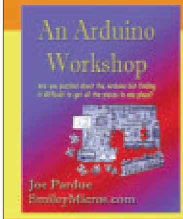

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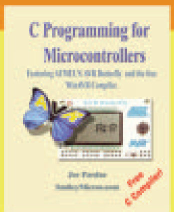

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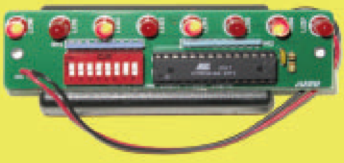

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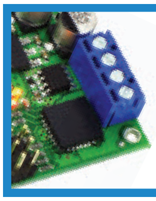

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#50 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

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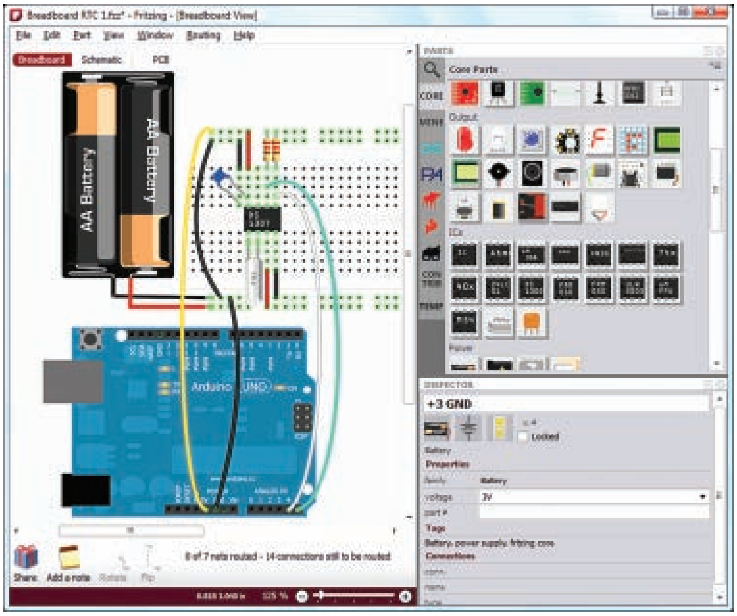
Fritzing With the Arduino — Part 2

Recap

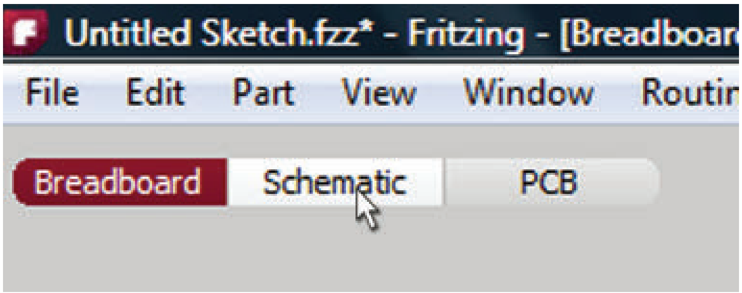
Last month, I introduced Fritzing — a novice-friendly hardware design package that we are using to design a real time clock shield for an Arduino. We saw how we can use Fritzing to design the prototype for it on a breadboard. This month, we will see how to take that breadboard prototype and generate a schematic design. Then — still using Fritzing — we'll convert it into a printed circuit board (PCB) layout that we will have manufactured for us by SparkFun's BatchPCB service.

One thing to remember while going through all this is that Fritzing is but one among many open source hardware design tools that let you draw schematics and generate PCB files. However, Fritzing is unique (as far as I know) in that it also lets you draw the circuit first on a breadboard that then automatically generates the schematic and PCB drawings.

For those of us who prototype with breadboards, this gives us not only an intuitive entry into the design, but it produces excellent drawings that we can use for documenting our projects. You'll see lots of Arduino projects on the Internet that use Fritzing for documentation. It is the clarity that the Fritzing drawings give that make this tool so popular.


Breadboard
Schematic
PCB
AA Battery
AA Battery
Arduino UNO
Parts
Core Parts
Inspector
+3 GND
Locked
Properties
Battery
voltage
3V
Share
Add a note
Rotate
Flip
0 of 7 nets routed - 14 connections still to be routed
125 %

■ FIGURE 1. Real time clock on a breadboard.


Untitled Sketch.fzz* - Fritzing - [Breadboar
File
Edit
Part
View
Window
Routir
Breadboard
Schematic
PCB

■ FIGURE 2. Select "Schematic."

The Schematic

To get things rolling, the breadboard illustration from last month is shown in **Figure 1**. The next thing you need to do is click on the Schematic button as shown in **Figure 2**. You'll see the schematic window with the schematic version of the breadboard parts scattered about as shown in **Figure 3**.

Now, let's move the parts to the positions that will facilitate adding the wires as shown in **Figure 4**.

Notice that as you move the parts around, tiny lines stick to the parts and stretch or contract a bit like a virtual rubberband. Those lines represent the part connections that you made in the breadboard. Similar to how you drew the wires on the breadboard, you use your mouse to grab a part connection point and stretch a line to the other end of the connection (refer to **Figure 5**). You may want to play around with this a bit, but keep in mind that your goal is not only to connect the parts, but to generate a schematic image that visually explains how the circuit is connected. This is not just about design; it is also about the very important and often underserved aspect of design: the documentation. To me, the image in **Figure 6** represents a typical way to show a design in a schematic format.

The Printed Circuit Board Layout

To open the PCB layout window, click on the PCB button shown in **Figure 7**. You'll get a raw layout something like what you see in **Figure 8**. Your goal here is similar to what you did with the schematic: You want to move the parts on the PCB so that the layout makes sense. And by sense, in this case, I mean that the parts are easiest to connect with PCB 'wires.' This routing of the wires is a skill that comes with lots of practice where you try what seems most logical, then rip up (delete the wire) and retry until you get something that seems optimal to you.

In **Figure 9**, we see the parts placed on the corner of the default PCB. Obviously, the default PCB is too large so we want to adjust it, *and then* ...

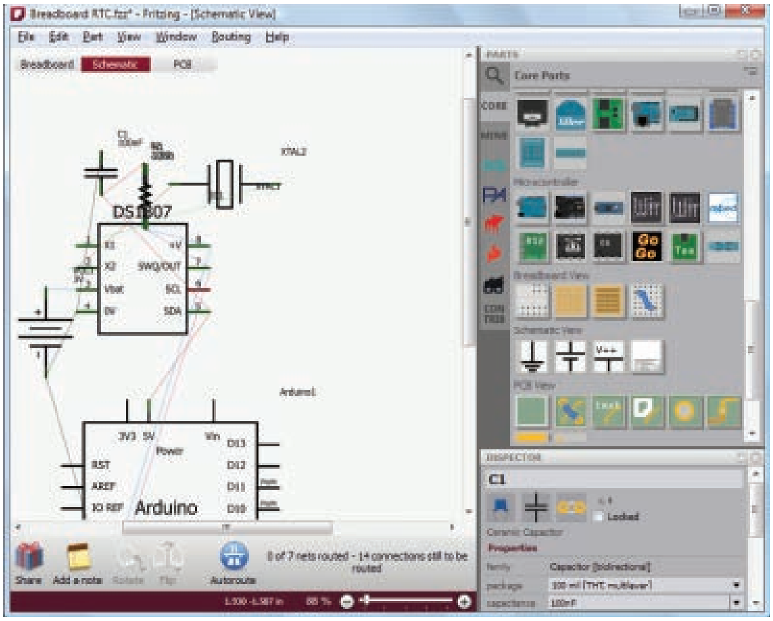
It Crashed!

Oh, the humanity! The blood was ankle deep ... *I WANT MY MONEY BACK! Oh wait ... this is free software in beta release, so I'll just live with this minor inconvenience and move on.* Although, this was a little more than a minor inconvenience. What I did was close my laptop to take somewhere with me and when I opened the laptop back up — NOTHING! Just a black screen and a forlorn arrow cursor that my mouse wouldn't move.

So, I waited 10 minutes hoping the microspirits would work some magic ... but nothing. I removed the battery to reset it and after taking forever to completely reboot, I got the message in **Figure 10** suggesting the Fritzing may have crashed. MAY HAVE!? *I WANT MY MONEY BACK!* (Okay, let's take a deep breath, remember the price and that it is beta, and see what we can recover.)

I clicked on the .fzz file and followed the suggestions. I renamed the file just in case, and as luck would have it I was able to recover the work. (**Yeah!**) It took a while to get back in business, but again the price is right and frankly I'm having fun with Fritzing. One thing I noticed when recovering the file is that for some strange reason it was saving my work in the Windows downloads directory, so I created a new directory under C:\Fritzing\mySketches and moved my files there. (I had to leave again, but this time I closed Fritzing before closing my laptop.)

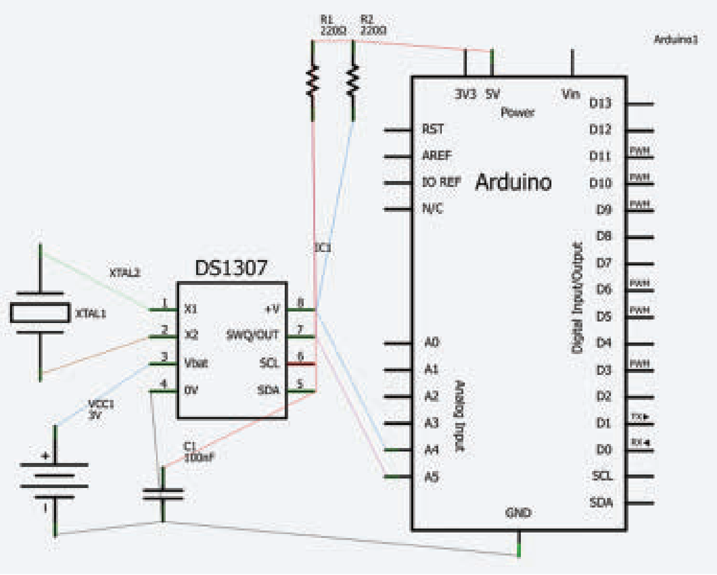
Next thing I did was resize the PCB to fit the Arduino pins so I can make this an Arduino shield,


Breadboard RTC.fzz* - Fritzing - [Schematic View]
File Edit Part View Window Routing Help
Breadboard
Schematic
PCB
C1 100nF
R1 220Ω
XTAL2
DS1307
X1
X2
Vbat
0V
+V
SWQ/OUT
SCL
SDA
Arduino1
3V3 5V Vin
Power
RST
AREF
IO REF
Arduino
D13
D12
D11
D10
Share
Add a note
Rotate
Flip
Autoroute
PARTS
Core Parts
CORE
MINE
INSPECTOR
C1
Ceramic Capacitor
Properties
Locked

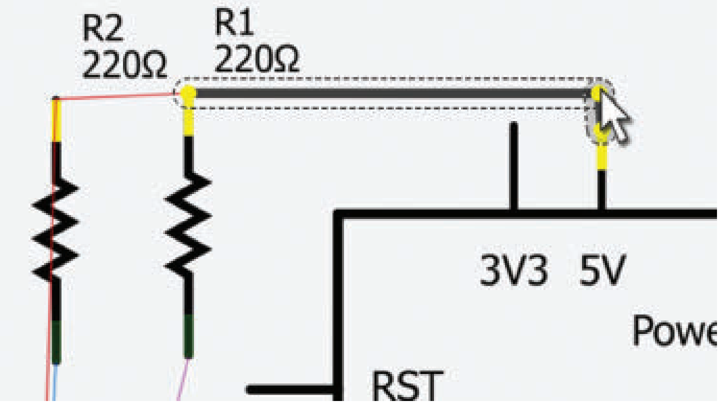
0 of 7 nets routed - 14 connections still to be routed

family	Capacitor (bidirectional)
package	100 mil [THT, multilayer]
capacitance	100nF

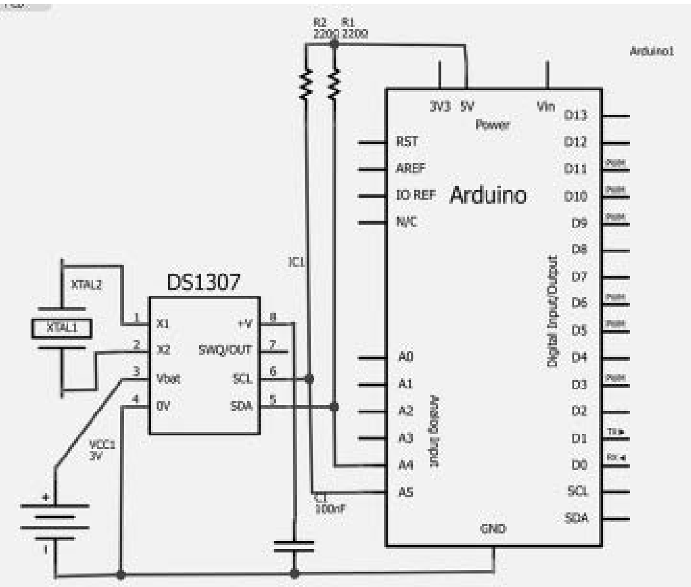
■ FIGURE 3. The schematic, not yet wired.


R1 220Ω
R2 220Ω
Arduino1
3V3 5V Vin
Power
RST
AREF
IO REF
Arduino
N/C
D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
D0
SCL
SDA
PWM
TX
RX
Digital Input/Output
A0
A1
A2
A3
A4
A5
Analog Input
GND
IC1
XTAL2
XTAL1
DS1307
X1
X2
Vbat
0V
+V
SWQ/OUT
SCL
SDA
1
2
3
4
8
7
6
5
VCC1 3V
C1 100nF

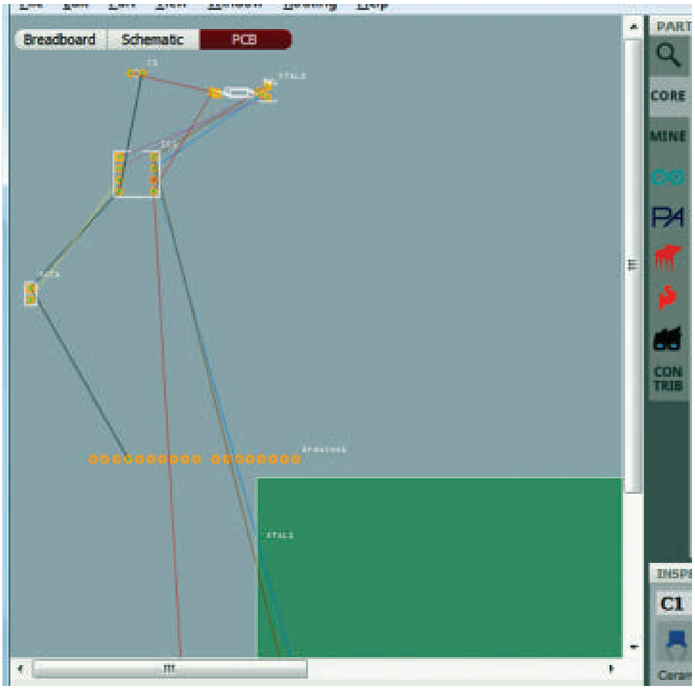
■ FIGURE 4. Reposition the parts.


R2 220Ω
R1 220Ω
3V3 5V
Powe
RST

■ FIGURE 5. Adding a wire.

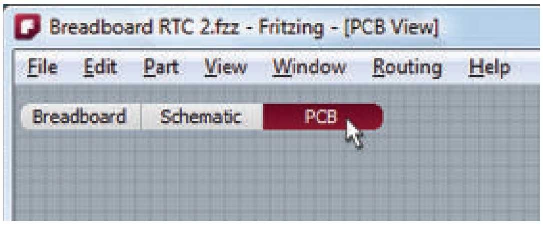

R2 220Ω
R1 220Ω
Arduino1
3V3
5V
Vin
Power
RST
AREF
IO REF
N/C
Arduino
D13
D12
D11
D10
D9
D8
D7
D6
D5
D4
D3
D2
D1
D0
SCL
SDA
PWM
TX
RX
Digital Input/Output
A0
A1
A2
A3
A4
A5
Analog Input
GND
IC1
DS1307
XTAL2
XTAL1
X1
X2
Vbat
0V
+V
SWQ/OUT
SCL
SDA
VCC1 3V
C1 100nF

■ FIGURE 6. The schematic, all wired up.

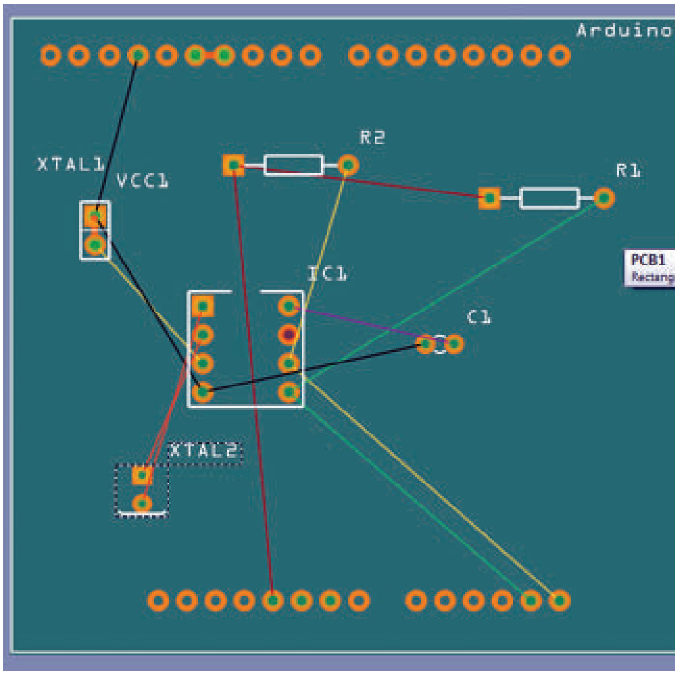

Breadboard
Schematic
PCB
PARTS
CORE
MINE
CONTRIB
INSPECTOR
C1

■ FIGURE 8. The raw PCB layout.

which is a PCB that plugs in on top of an Arduino. Next, we move the parts. Notice that you can move the parts anywhere, but that isn't such a good idea when designing a PCB. In fact, you want to move parts to specific locations in relation to each other. Often, we have parts that have pins that are on 0.1" centers, so let's set up a grid where parts can be moved around, and land on 0.1" points in relation to each other. We see in **Figure 11** that we can check the "Align to Grid' and 'Show Grid' selections in the View menu; we get the grid shown in **Figure 12**.


Breadboard RTC 2.fzz - Fritzing - [PCB View]
File
Edit
Part
View
Window
Routing
Help
Breadboard
Schematic
PCB

■ FIGURE 7. Select "PCB."

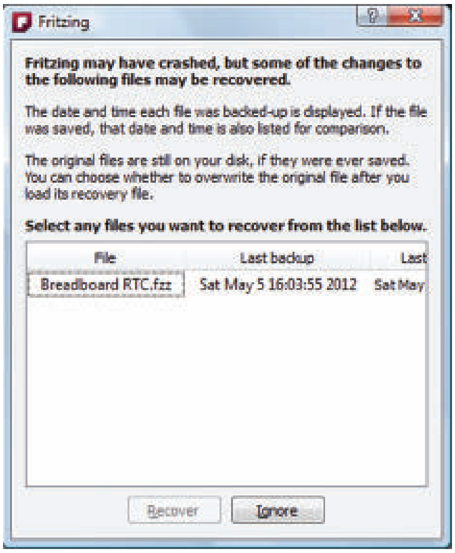

Arduino
XTAL1
VCC1
R2
R1
PCB1
IC1
C1
XTAL2

■ FIGURE 9. Moving parts to the board.

Now, let's move these parts to reasonable positions and add the wires. First thing you'll notice is that every time you try to grab a part, you end up grabbing the Arduino! To prevent this, you right-click on the Arduino part, select 'Lock Part,' then click 'Raise or Lower.' Select the 'Send to back' option. Now you can move the other parts that are sitting on top of the locked Arduino layer.

In **Figure 13**, I've moved the parts to the lower right corner conveniently located to each other's pins for wiring. The lines connecting the pins are called the rats nest (though I can't imagine why) and they act like rubber bands, indicating where the PCB wires are to go. Your goal is to get the rats nest minimized so the wires can be as short as possible. Next, note that the battery terminal doesn't have any indicator of which pin goes to GND and which goes to the +3 volt line of the battery, so I right-click on the VCC1 label for the part which gives me the window shown in **Figure 14**. I then change the VCC1 to 'GND +3.' I rotate the text and place it next to the connector as shown in **Figure 15**.

Fritzing has an auto-router, but we won't use it since this is a very small board and I find routing is fairly intuitive. You just click on a pin and move the wire to the next connection and release it. **Figure 16** shows what happened when I wired the VCC, GND, and crystal pins.



Fritzing

Fritzing may have crashed, but some of the changes to the following files may be recovered.

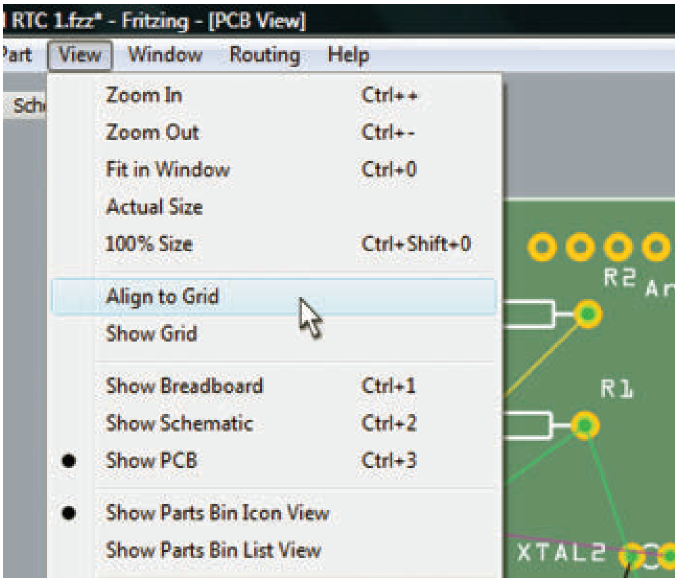
The date and time each file was backed-up is displayed. If the file was saved, that date and time is also listed for comparison.

The original files are still on your disk, if they were ever saved. You can choose whether to overwrite the original file after you load its recovery file.

Select any files you want to recover from the list below.

File	Last backup	Last
Breadboard RTC.fzz	Sat May 5 16:03:55 2012	Sat May

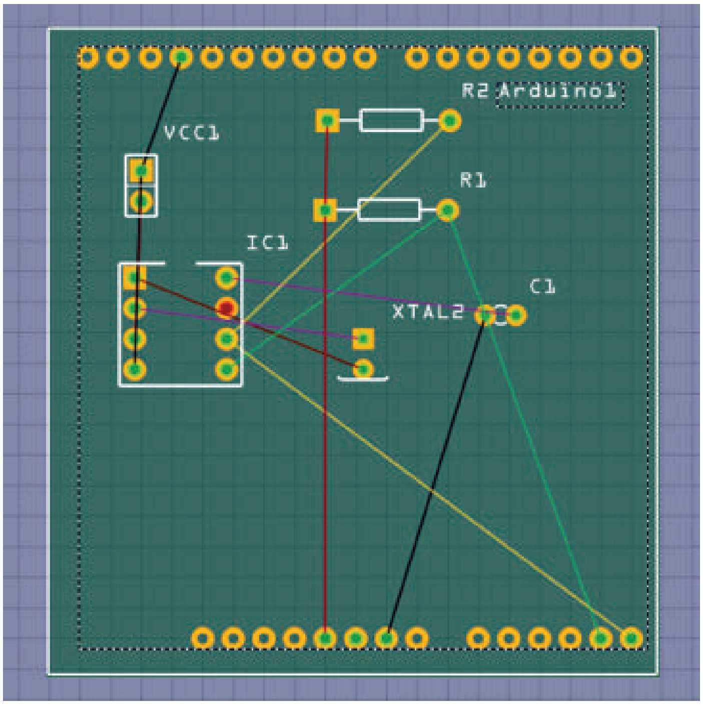
■ FIGURE 10. Fritzing may have crashed.



RTC 1.fzz* - Fritzing - [PCB View]

■ FIGURE 11. Align to Grid.

I then noticed something that I should have seen earlier (had I been paying attention). The battery wires will cross each other on their way to the DS1307 which would require either two layers or some funky routing. Also, the I²C wire on the left to R1 from the Arduino doesn't have enough room to be routed. So, I flipped the battery terminal and moved the resistors up, and tried again.



■ FIGURE 12. PCB parts on the grid.

In **Figure 17**, we see my first finished wiring attempt. I couldn't figure out how to change the grid size, so I shut it off and carefully routed the wires. As an experienced PCB designer, I immediately noticed something quite scary. Wires on a PCB are called traces. The traces and the pads on the right of the DS1307 look like they short out. In my experience, I can set the size of the traces and the parts pads so that I would normally be able to route a trace between IC pins, but it sure doesn't look like that will work here. Will this mean that I'm going to have to use two layers so that I can drop those wires to the bottom, and route them up and over?

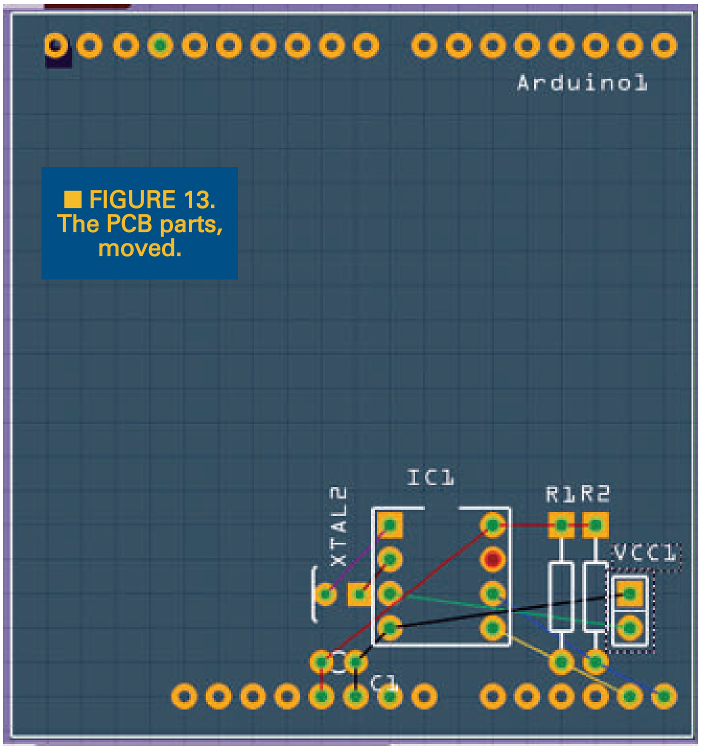
Well, let's hope what Fritzing is showing us isn't what it generates for the final PCB file. So, click on the 'Export for PCB' and the 'Etchable (PDF)' as shown in **Figure 18**. This gives us five PDF files — one for each layer. Let's look at the '...etch_bottom_copper.pdf' shown in **Figure 19**. See those red circles? Yes, we have a problem!

Okay, I'm used to being able to set the pad and trace dimensions, but Fritzing doesn't seem ready for that. Let's reroute the troubling traces on the opposite side and see what we get.

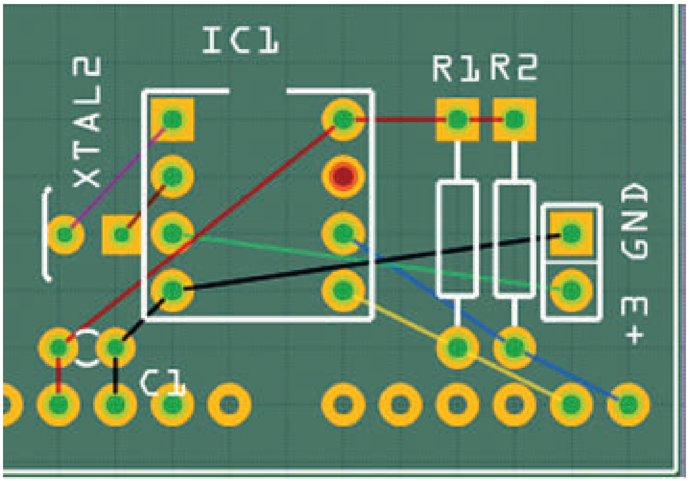
To fix this, we click on the problem traces and change the side from bottom to top as shown in **Figure 20**. Then, reroute them up and over to the battery terminal BUT notice that we still have a problem since these traces will have to cross — unless we flip the battery terminal back like it was to begin with (sigh!). The results are shown in **Figure 16**. Yes, I could have shown all this in the correct order to begin with, but I think it is helpful to see the actual problems I ran into and how I fixed them. The resulting top and bottom layer are shown in **Figure 21**.

Actually, take a long hard look at **Figure 21**. Ask yourself if this is the final wiring or could you perhaps make some minor changes and get all the wires on one side of the board. Well, it's possible, but since my goal here is to produce a PCB design that can be sent to a fab house (where someone else will do the work), we'll just leave it.

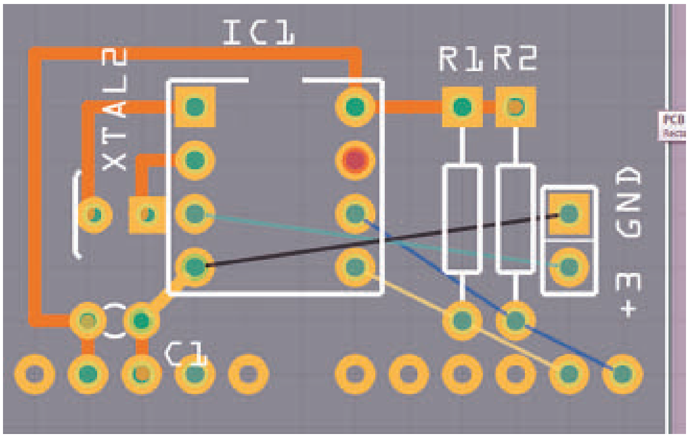
I have to say that making a board with all that free space and the entire upper row of Arduino pins gives me the creeps — so much wasted space. Since we are making an Arduino shield we actually need all those pins so that we can — theoretically — mount another shield on top of the one we are making. [BTW, I found that you can — in


Arduino1
IC1
XTAL2
R1 R2
VCC1
C1

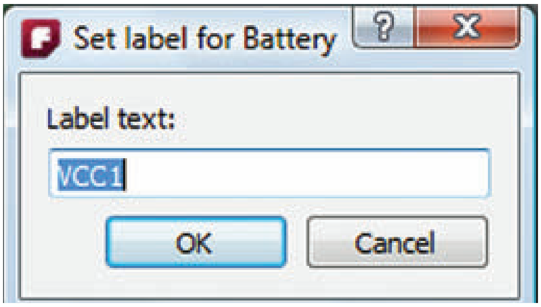
■ FIGURE 13. The PCB parts, moved.


IC1
XTAL2
R1 R2
GND
+3
C1

■ FIGURE 15. Ready to route the wires.


IC1
XTAL2
R1 R2
GND
+3
C1

■ FIGURE 16. First attempt at wiring.

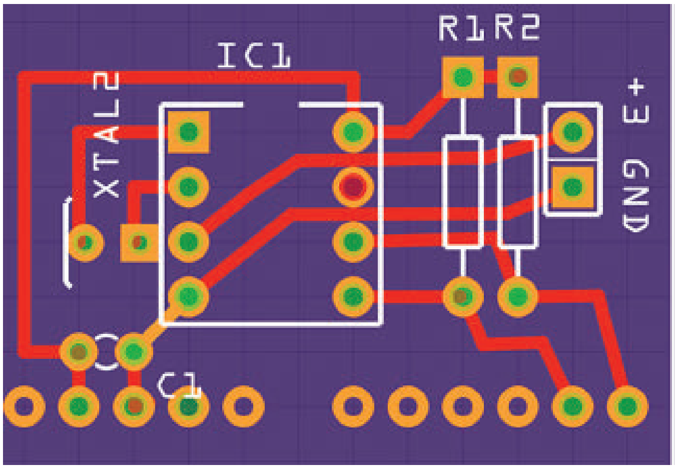

Set label for Battery
?
X

Label text:

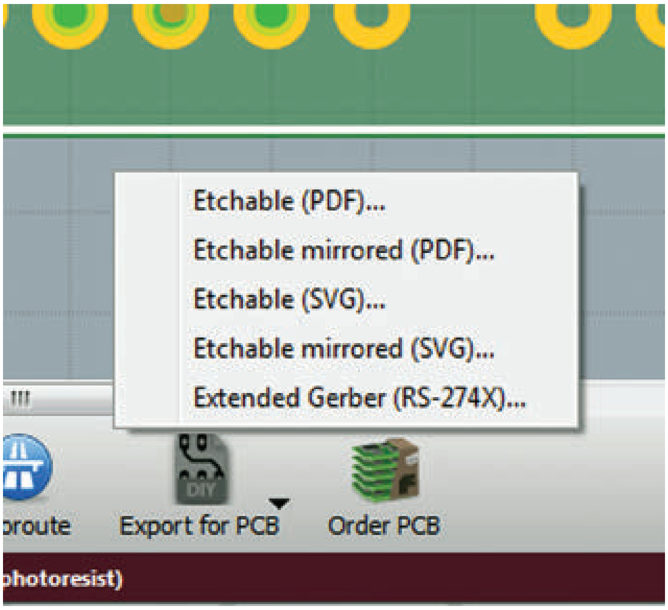
VCC1

OK
Cancel

■ FIGURE 14. "Label text."


IC1
R1 R2
XTAL2
+3
GND
C1

■ FIGURE 17. First finished wiring.

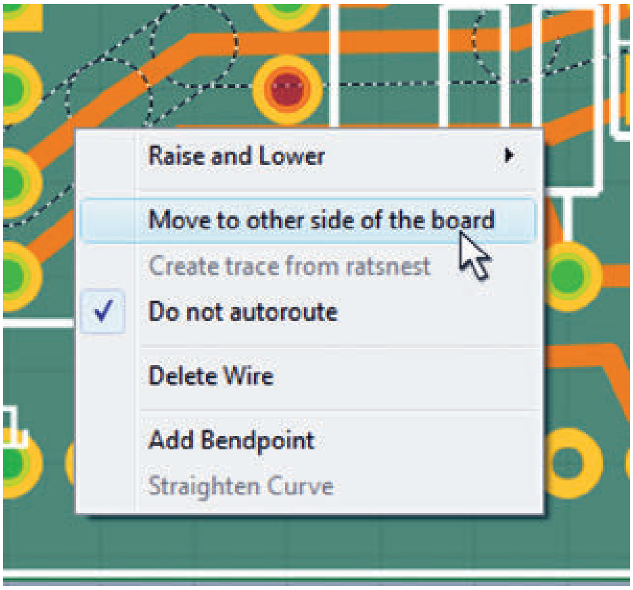

Etchable (PDF)...
Etchable mirrored (PDF)...
Etchable (SVG)...
Etchable mirrored (SVG)...
Extended Gerber (RS-274X)...
route
Export for PCB
Order PCB
photoresist)

■ FIGURE 18. Export for PCB.

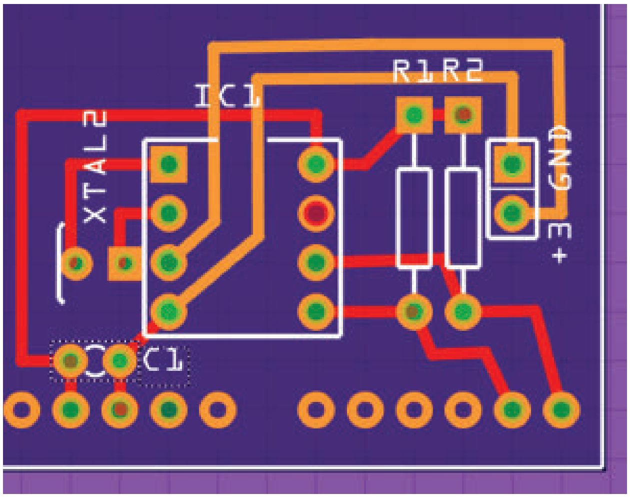
fact — change the wire size in Fritzing! Just highlight the trace in question and you can change the width in the Inspector window Width dropdown box to 16, 24, 32, or 48 mils.]

Sending It Out to a PCB House

Fritzing has a feature that lets you get your board


Raise and Lower
Move to other side of the board
Create trace from ratsnest
✓ Do not autoroute
Delete Wire
Add Bendpoint
Straighten Curve

■ FIGURE 20. "Move to other side of the board."


XTAL2
IC1
R1 R2
GND
3E
+
C1

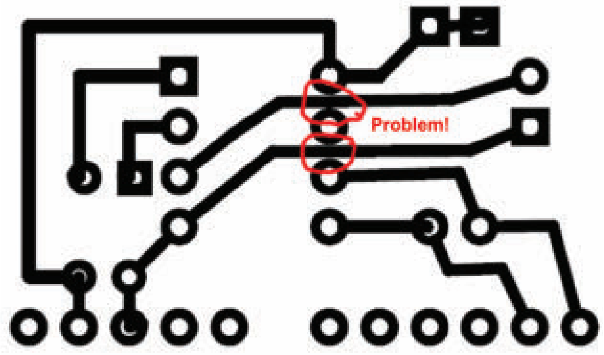
■ FIGURE 21. Is this the final wiring?

fabricated in Europe. For an Arduino shield, it costs $38 + shipping. Frankly, I'd like to see these guys get rewarded for their efforts (which would also give them incentive to improve their product), but I know there are much less expensive options for those of us in the US, so let's take a look at one: SparkFun's BatchPCB. Of course, there is always a down side for every choice. BatchPCB is cheaper but it takes longer to get the board (to the US, 3-10 days for Fritzing; 3+ weeks for BatchPCB).

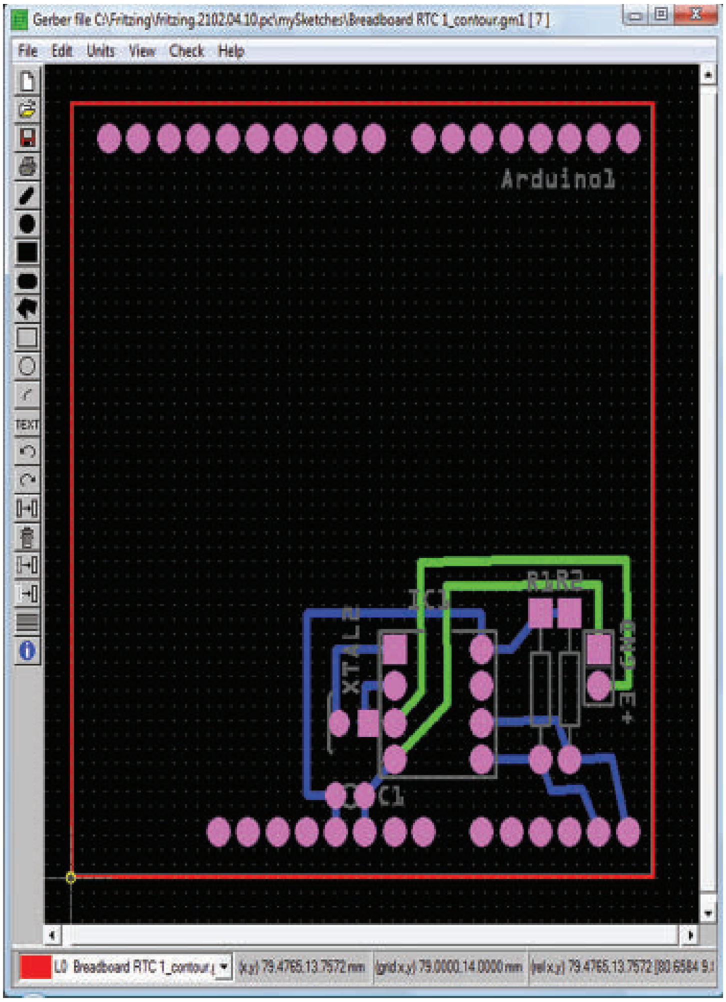
I chose BatchPCB to fabricate this board since it is relatively cheap and easy to work with. Be aware though that none of the fab houses are exactly novice friendly and you have to eat your mistakes. Fortunately, making mistakes and living with the consequences is one of the best ways to learn.

PCB fab houses require files in certain specific formats. We'll use the Gerber format supported by Fritzing. Notice that the Fritzing 'Export for PCB' has an 'Extended Gerber (RS-247X)...' option, so let's go with that. This generates the following files:

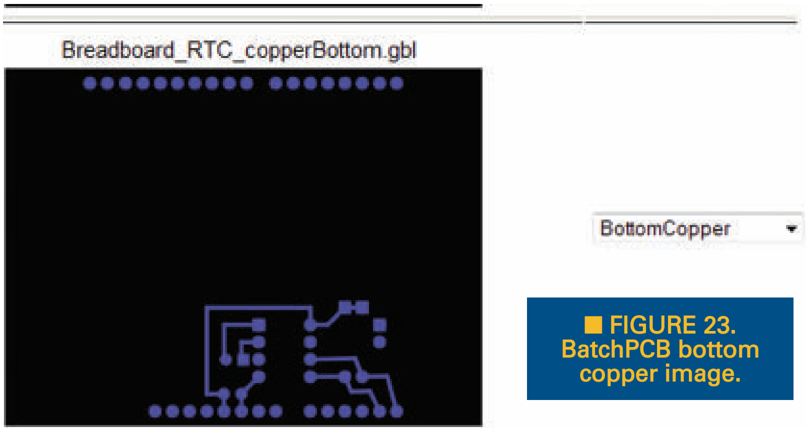
Breadboard RTC 1_contour.gm1
Breadboard RTC 1_copperBottom.gbl



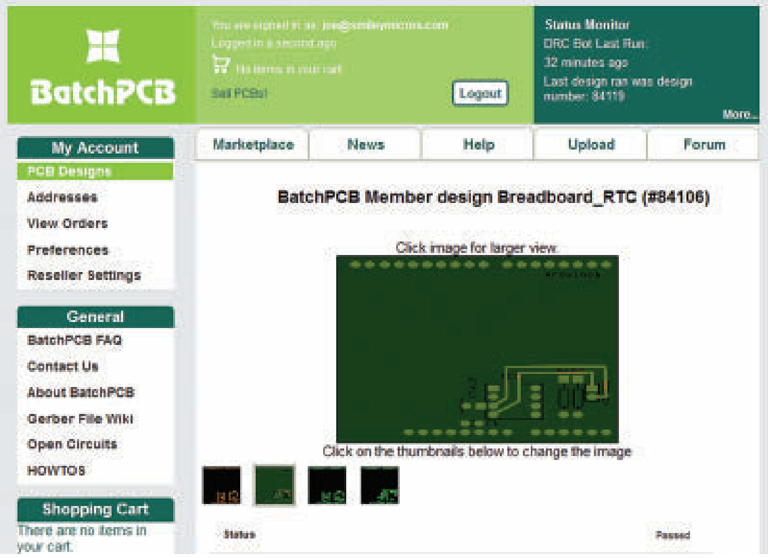
■ FIGURE 19. PCB — we have a problem.


Gerber file C:\Fritzing\fritzing.2102.04.10.pc\mySketches\Breadboard RTC 1_contour.gm1 [7]
File Edit Units View Check Help
TEXT
Arduino1
IC1
R1 R2
XTAL2
GND
3E
+
C1
L0 Breadboard RTC 1_contour

■ FIGURE 22. The RTC shield in Viewplot.


Breadboard_RTC_copperBottom.gbl
BottomCopper

■ FIGURE 23. BatchPCB bottom copper image.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BatchPCB Member design Breadboard_RTC (#84106)

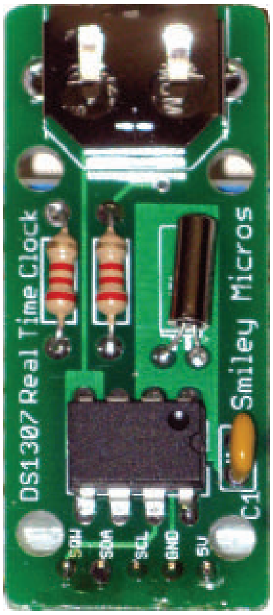
Click image for larger view.

Click on the thumbnails below to change the image

There are no items in your cart.

■ FIGURE 24. BatchPCB ready to build.

These two parts of the Fritzing tutorial show you how to design and build your own DS1307 based real time clock, but if you just want one to play with you can purchase the DS1307RTC kit which contains all the parts you'll need including a PCB (better than the one we designed here) that we discussed in Smiley's Workshop in the July issue. Of course, you can get it from the *Nuts & Volts* Webstore.


DS1307 Real Time Clock
Smiley Micros
C1
SQW
SDA
SCL
GND
5V

■ FIGURE A. The DS1307RTC kit.

Breadboard RTC 1_copperTop.gtl
Breadboard RTC 1_drill.txt
Breadboard RTC 1_maskBottom.gts
Breadboard RTC 1_maskTop.gts
Breadboard RTC 1_silkTop.gto

Look at the Files in Viewplot

You can get Viewplot for free at **www.viewplot.com**. Click 'File' and 'Load files,' then navigate to the Gerber files in your Fritzing directory and load them.

You'll get a couple of cryptic windows, but just click okay on them and you'll see something like what is shown in **Figure 22**.

Viewplot gives you the opportunity to carefully inspect each layer before sending it to the fab house. I won't go into the details on how to use Viewplot since it is fairly intuitive.

Our board is pretty simple and there doesn't appear to be any potential problems, so let's submit these files to BatchPCB and let them run them through some programs that look for common errors.

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Onward to BatchPCB

Take a look around **www.BatchPCB.com** and get familiar with what they do. They have lots of stuff to help you. Let's put all our Gerber files into a single zip file that we'll call Breadboard_RTC.zip. Click on the 'Upload New Design,' then name the design and upload the zip file. To use their service, you must rename some of your files. Rename ...drill.txt to ...drill.drl and ...contour.gm1 to ...contour.oln.

BatchPCB uploads the files and shows you an image of each layer; **Figure 23** shows the bottom copper layer.

They will then provide you with board statistics. The important one here is that the board is 4.25 square inches; they charge by the square inch which, in this case, will be $10.62 – not too bad.

They also generate pictures similar to what we saw in Viewplot. (**Figure 18** shows the bottom copper layer.) Finally, BatchPCB generates a picture for you to order from as shown in **Figure 24**.

Well, $10.62, plus $10.00 for handling, plus $5.65 for shipping so $26.27. I could order more at $10.62 each and the handling charge and shipping stay about the same so each additional one is proportionally less, but one will do for this learning exercise so one is enough.

[BTW — you can get boards much cheaper from China, but it is also more complex so we'll reserve that option for a later Workshop.]

Now We Wait ...

BatchPCB works — as its name implies — in batches. That is, it waits till it has a big enough *batch* of boards to fill a PCB panel. It then gets sent to Gold Phoenix in China who makes the full panel, then cuts out all the boards in that batch.

This process takes an unknown amount of time since your board might be the last one on the panel so it gets sent off quickly, or the first on the next panel meaning it has to wait.

So, how long will we have to wait? Tune in next month and find out. **NV**

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Continued from page 24

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Global Specialties has updated their line of solderless breadboarding systems. Their family of prototyping and training products — which includes four RoHS compliant items — utilizes Global's new highly durable ABS transparent breadboarding sockets. These transparent ABS sockets allow for easy viewing of prototyping connections and reduce circuit construction time and verification, making them perfect for educational applications. The new products include the GS-100T (100 tie points), GS-630T (630 tie points), and GST-830T (830 tie points) solderless breadboards, and the PB-10TE Proto-Board™ with 1,360 tie points. All products come blister-packaged and are available to ship from stock.

For more information, contact:
Global Specialties
www.globalspecialties.com

FAST-SWITCHING, LONG RANGE WIRELESS LINK

Lemos International has launched the new WFX2 radio transceiver module. Designed for applications requiring long range and high reliability, the WFX2 offers fast switching together with +27 dBm (500 mW) RF power output and ETSI Category 1 (Class 1) receiver performance.

This new 256 channel module features an exceptional RX-to-TX switching time (5 ms), has a receive sensitivity of -118 dBm, and can achieve a usable range of over 5 km over open ground. The feature rich interface offers analog RSSI and both logic level and analog baseband inputs and outputs. A four-way internal channel select switch is standard.

The compact WFX2 (85 x 55 x 13 mm) requires a regulated +5V DC power supply and is re-programmable via a microcontroller UART interface, drawing 35 mA in receive and under 400 mA in transmit.

Multiple versions of the product are available; the standard 458 MHz module offers data rates of up to 5 kbps; the WFX2-458-G variant is to be used with an external 9600 baud GMSK modem; and a dedicated modem version — the WFZ2 — has an internal M48 modem. A 12.5 kHz narrowband version is also available.

RADIOMETRIX
WFX2-458-5

The WFX2 is ideally suited to applications including on-site paging; telecommand tasks; machine control; fast, long range data modems; and robotic/mechatronic control functions.

This module is the latest addition to a new range of high power transceivers from Radiometrix which includes the SHX1-169-5 transceiver on VHF frequencies and the FPX3-869-10 — available on the pan-European 869.4-869.65 MHz band.

For more information, contact:
Lemos International
www.lemosint.com

WI-FI TEMPERATURE AND HUMIDITY DATA LOGGING SENSOR

Saelig Company, Inc., introduces the EL-WiFi-TH — a Wi-Fi connected temperature and humidity sensor for monitoring the environment in which it is situated.

MAX
MIN
°C°F
%RH
EL-WIFI-TH
WiFi

Data is transmitted wirelessly via a 802.11b-compliant network to a PC, and can be viewed using the free graphical software package supplied. The EL-WiFi-TH can be placed anywhere within range of a chosen network. If the sensor should temporarily lose connectivity with the network, it will log readings until it is able to communicate again with the PC application (max 60 days at 10 second sample intervals). Additionally, the range of the sensor can be increased by using Wi-Fi extenders.

The EL-WiFi-TH is a low-power device that includes a rechargeable internal lithium polymer battery. When configured using typical sampling periods (e.g., once every 60 seconds), the sensor will operate for over one year. The battery can then be recharged via a PC or USB +5V wall adapter using the USB cable provided. The included PC software

CLASSIFIEDS

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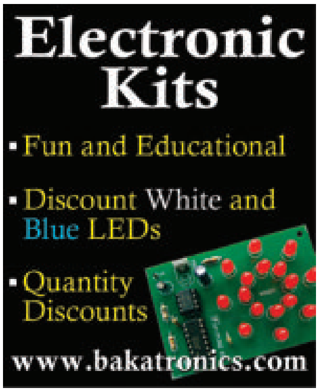
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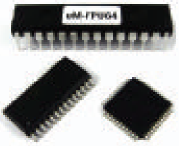

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will allow setup, data logging, and data review for multiple sensors, including immediate graphing of historic data. The EL-WiFi-TH features a built-in LCD screen which can display max and min readings, low battery indication, and Wi-Fi connection strength.

With a measurement range from -20°C to +60°C (-4°F to +140°F), the EL-WiFi-TH is capable of logging more than 500,000 data set entries. It is suitable for a wide variety of applications — particularly where remote monitoring is important — including environmental and weather monitoring, agricultural and livestock, building and site monitoring, and HVAC.

The EL-WiFi-TH is supplied complete with a wall bracket and micro USB cable for $179.95 (software available as a free download).

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>>> QUESTIONS

Differential Thermostat

Currently I am using two thermostats to activate an attic fan: one thermostat to determine a cool outside temperature and a second thermostat to determine the attic temperature. When the differential between the two reaches the set point of the two, they both turn on the attic fan, pulling cooler outside air up and through the attic. This only works when each thermostat reaches their "set" point temperatures. I would really like to be able to have the fan come on when a variable differential temperature — say 20 degrees — is reached, regardless of outside or attic temperatures; also, only if the attic temperature is warmer than the outside temperature.

#9121 **Vonn Hockenberger**
Livermore, CA

How Long Does My Furnace Run?

I need to see how long my furnace blower motor runs and track the overall time in a digital display. I would need a reset button to reset the time when needed. I have a switch that activates when power is sent to the motor line. Can I get components and a design or a kit somewhere?

#9122 **Jeff Barto**
via email

3D Location System

I am trying to build a close-range 3D location system that works within about a 10 ft square area.

I need X, Y, and Z coordinates from one fixed point; then record the points into a computer.

I prefer a laser based system that records its rotation in degrees and for both Z and X axis and the length of the laser to the object for a calculated Y coordinate.

#9123 **Jim**
Monte Sereno, CA

Programmable Equalizer

I want to design an inexpensive audio graphic equalizer that us older guys (and ladies) can use with our radio (ham) gear. What I envision is a programmable equalizer that can be programmed to boost frequencies based on hearing tests. Even better would be a stereo equalizer that can be used with a stereo headset to allow us old timers to hear better.

#9124 **Jim Darrough**
Springfield, OR

A/C Mod

I have a central A/C unit and the inside fan blower has a control module referred to as an "r" mod. It has a few components on it and is designed to kick-start the fan motor. I can't afford the $1,200 to get it replaced. Can I just replace the bad components on the module? It looks like two small capacitors and an electromagnet. It's a Carrier Tech 200 SS.

#9125 **Omar Deeb**
Winter Garden, FL

1960s' Tube Amp Volume Control Behavior

When I was in high school, there was a Newcomb institutional phonograph — 12-inch speaker and vacuum tube circuitry. My friend pointed out that when the volume control was not rotated clockwise far enough, the music was "thin." There came a point, however, that with further rotation of the volume pot the sound became full and lush. I would love to know what was going on in the circuit to cause that behavior.

#9126 **James Gibbs**
Cedar Rapids, IA

IC Identification

I'm attempting to repair a PC board for a RadioShack PT Cruiser remote control car. The IC (20-pin) has the following numbers printed on the top: S111g, KJET IC001, OU97112.

In the tech manual, the IC is identified as KS57C0301.

(1) Program memory is 1K byte (KS57C0301) and 2K byte (KS57C0302).

(2) Data memory is 128x4 bit (KS57C0301) and 256x4 bit (KS57C0302).

Parts from RadioShack are no longer available. Any help in identifying a substitute would be appreciated.

#9127 **Tom Recker**
Peoria, AZ

S-KMS Recliner Chair

I'm trying to repair a microprocessor controlled massage chair, imported by HWE, Inc., Los Angeles. ID S-KMS mfg # 000101, additional number 61011-L.

NEC is the processor manufacturer and has indicated in thier product description that the processor is a uPD75004CU four-bit discontinued part. I am reasonably sure there is an onboard program, but do not know enough about it to get it into test mode.

It appears to be completely shut

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down. I have scoped the in and out, but there is no activity.

If the processor is dead, then a $1,500 item is junk, unless someone can help.

I would like to have a schematic, service manual, literature, or advise.

#9128 **Ken**
Martindale, TX

My FM Radio Hates My New High Output Fluorescent Lighting

I have installed some 8' HO fluorescent lights, and now the FM radio has too much noise.

I put four snap-on RF chokes on the power cord at the radio. They did reduce some of the interference and I even plugged the line into a surge protector.

Is there anything I can do at the fixtures to knock out this RF problem?

#9129 **David Robin**
Howell, MI

Wireless Water Level Monitor/Indicator

I'm looking for a schematic solution to wirelessly indicate the water level of a distant water tank more than 100 m away.

#91210 **Janaka**
via email

>>> ANSWERS

### [#7124 - July 2012]
Garage Door Sensor

What's the best way to hack the garage door sensor so that when the garage door is open, anything breaking the light beam will trip a relay?

#1 This will vary from one garage door opener to another, but most that I've seen have an LED either on the photo beam receiver or on the opener itself that illuminates when the beam is intact. If I wanted a relay to trigger, I would tap into this LED. If you want to interface to it without modifying anything, a phototransistor or CdS cell could be mounted over it to detect light from the LED. Anything else will require some reverse engineering on your particular opener.

James Sweet
via email

#2 I did something similar with a toy called "Laser Shot" that was sold by RadioShack years ago.

I wanted the target to flip a relay. I used an astable multivibrator circuit — I believe I used the 555 timer to a 7400 series counter, which then drove a transistor, which held the relay on or off.

In any event, you need to poke around until you find anyplace where the voltage changes when the light beam is broken. Then, you take that voltage and clean it up for your circuit to use.

I used the 555 in astable mode. It would trip into the unstable voltage, wait for some time, then flip back to the stable state. (This may not work for something blocking your light beam, depending on what you want your circuit to do when the beam is continually blocked.) The Laser Shot had a measurable time it was making noise, or time the circuit would trigger the noise generator. All I had to do was get a clean pulse from the 555 to a counter circuit, where the lowest bit was used to drive the transistor which then held the relay open or closed.

Your circuit may be simpler. You may only want the relay to flip when the beam is broken and then flip back once the beam path is cleared. You didn't say.

Phil Karras
via email

### [#7125 - July 2012]
CCD/CMOS Camera Back

One of my deepest desires has been to "resurrect" my film cameras as digital. Is it at all feasible to construct some sort of relatively compact and usable CMOS or CCD device which can be attached to an existing camera that would yield high resolution images to be stored on a standard memory card? If so, could a diagram and list of materials be provided? I would prefer a full format sensor for use on a full format 35 mm camera, but a smaller format sensor would be acceptable for attachment to microscopes or telescopes.

The biggest issue with what you would like to do is that typical CCD sensors are a fraction of the size of a 35 mm film frame. In order for the existing optics to focus properly onto the sensor, it has to be located in the same plane the film would be. If you install a 1/3 inch CCD in a 35 mm film camera, you will only be capturing a small portion of the field of view. Anything is possible with enough effort, but given the low price of some very good digital cameras these days, you are better off buying one than trying to convert something and ending up with inferior results.

James Sweet
via email

### [#7126 - July 2012]
Schematics and Components

I don't know that much about reading circuit diagrams, but in theory, if I bought all the components in a given diagram, could I simply connect each component to the others as shown in the schematic? I have seen references to using a breadboard but from what little I've read, they are configured in various ways and I wouldn't know what configuration a given project might require.

I understand that soldering component leads together with no substructure or framework might look like a piece of modern art, but could I do that and expect it to do what it is supposed to — whatever that is?

#1 Whether you can simply connect components as shown in the schematic without regard to parts layout and lead dress depends entirely on the project.

For "DC" projects, such as a demonstration of an AND gate with two switches, an LED, perhaps an IC, a few resistors, and maybe a bypass capacitor, parts layout isn't critical so long as the bypass capacitor (from Vcc to ground) is physically close to the IC. It would even be okay to solder component leads together with no substructure or framework.

On the other hand, for radio frequency work (FM receivers, AM receivers, garage door openers, etc.), and for any project with a microprocessor, parts layout is critical, and you should follow the perfboard layout or printed circuit layout published with the schematic. If you don't, stray inductance and capacitance can wreak havoc with the circuit, and unwanted oscillation may even occur.

In between are audio frequency projects. For high impedance projects — generally those with a low level signal input — layout is critical.

However, for low impedance projects — such as a circuit to drive a speaker from the output of an MP3 player — layout isn't critical.

John Herro
Cincinnati, OH

#2 There are plenty of examples of building circuits without a PC board available on the net; **http://blog.makezine.com/tag/freeform/** is an excellent example of this type of freeform circuit building. It is sometimes a little more complicated than using a printed circuit board pattern, but for some circuits, it's more practical. As long as no leads touch where they shouldn't and as long as stray capacitance isn't an issue, the circuits will function just fine.

Derek Tombrello
via email

#3 Yes, you can wire parts together in free air following the schematic and in most cases, it will work just fine. Indeed I have done just this on a few occasions, either to lash up a very simple circuit to test or for artistic reasons. In general though, I would recommend other techniques for day to day use. Do some searching online for electronic prototyping and building techniques; there are countless methods that have been developed over the years and you are sure to find something suitable.

Perfboard is a good simple one that I've used many times. I would also recommend becoming proficient at reading schematics and identifying components prior to jumping in. It will save you much time and headaches in the long run.

James Sweet
via email

### [#8121 - August 2012]
Cell Phone Amplifier

I need a parts list and schematic to build a cell phone amplifier to connect to standard headphones.

A LM386 based circuit would be simple and will run from a 9V battery. See **http://web.mit.edu/6.s28/www/schematics/lm386.htm**.

You can also buy a small kit such as at **www.electronics123.com/kits-and-modules/audio-amplifier-1W-LM386-kit.html**.

If the output sounds too harsh, drop the gain by removing the feedback cap (C1 in the diagram at the first link).

Jim Sluka
Greenwood, IN

### [#7127 - July 2012]
RF Chip for Fuel Tank

Has anyone heard of a RF chip which attaches to the fuel tank of a vehicle and supposedly provides high frequency output which increases fuel mileage?

While I haven't heard of the "RF chip" you refer to, I have seen a great many miracle gadgets over the years claiming to increase your fuel economy. All of them, of course, come with grand claims and glowing testimonials, but invariably the only thing they do well is extract money from your wallet. There is only so much energy in a gallon of fuel and modern engines do very well at burning fuel efficiently and extracting as much of that energy as possible. The inherent inefficiency in an internal combustion engine comes mostly from the process of turning heat into mechanical motion, not inefficient creation of heat from fuel. You can't argue with the laws of physics.

James Sweet
via email

### [#8122 - August 2012]
Powering a Hydrogen Generator

I'm building a HHO generator and am trying to figure out the best way to power it, keeping the power usage low. A high voltage, low amp method like using a Tesla coil might do the trick. Any ideas to help me figure it out?

First of all, try to avoid the term "HHO" — it makes you look like a crackpot. Electrolysis of water produces a mixture of molecular hydrogen (H2) and molecular Oxygen (O2) in a 2:1 ratio. There is no such thing as "HHO."

Second thing to know is that no matter what you do, the energy into the system is more than the energy you get back out of the system. If you put in one Joule of energy to break the water into H2 and O2, you will get back less than one Joule when the H2 and O2 is recombined. That's the laws of thermodynamics and you can't break those laws.

Now, what are you really trying to do? You mention a Tesla coil but that is a high voltage, low current system. Electrolysis cells are intrinsically low voltage, high current devices. To electrolyze water, you only need about two volts per cell. Using higher voltages doesn't accomplish anything useful; indeed higher voltages just mean that you will get electrolysis reactions you don't want, as well as significant energy loss due to ohmic heating. So, it would be really silly to take an energy source and use that to run a Tesla coil, then use that output to run the electrolysis rig. If you are thinking of using the Tesla coil to pull power out of say ... atmospheric RF (basically using the coil as an RF antenna), then you have to go back to my earlier point about energy in > energy out. How much "free" energy can the coil actually capture from the atmosphere? RF waves are extremely low energy; even with a big antenna, you are not going to be able to capture enough energy to light even a single LED. So, running an electrolysis cell might be possible but it isn't going to generate enough fuel to make it worthwhile.

One last thing. H2 + O2 is explosive. The Hindenburg didn't explode, it combusted. A mixture of H2 + O2 ***WILL*** explode, and that explosion will be much more energetic than what occurred with the Hindenburg. Add in the worry that any electrolysis cell produces gases that can be compressed along with heat, and you have two pathways to an explosion: combustion and over-pressurization of the H2 + O2 storage tank.

Jim Sluka
Greenwood, IN

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Back To School Time!

Build It, Learn It, Achieve It, and ENJOY

Super-Pro FM Stereo Radio Station

- ✔ **PLL synthesized for drift-free operation**
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- ✔ **Frequency range 88.0 to 108.0, 100 kHz steps**
- ✔ **Precision active low-pass "brick wall" audio filter!**
- ✔ **Dual LED bar graph audio level meters!**
- ✔ **Automatic adjustable microphone ducking!**
- ✔ **Easy to build through-hole design!**

This professional synthesized transmitter is adjustable directly from the front panel with a large LED digital readout of the operating frequency. Just enter the setup mode and set your frequency. Once selected and locked you are assured of a rock stable carrier with zero drift. The power output is continuously adjustable throughout the power range of the model selected. In addition, a new layer of anti-static protection for the final RF amplifier stage and audio inputs has been added to protect you from sudden static and power surges.

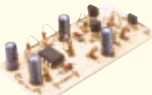
Audio quality is equally impressive. A precision active low-pass brick wall audio filter and peak level limiters give your signal maximum "punch" while preventing overmodulation. Two sets of rear panel stereo line level inputs are provided with front panel level control for both. Standard unbalanced "RCA" line inputs are used to make it simple to connect to the audio output of your computer, MP3 player, DVD player, cassette deck or any other consumer audio source. Get even more creative and use our BS2 Bullshooter-II (see our website or catalog) for digital storage and playback of announcements and ID's! In addition to the line level inputs, there is a separate front panel microphone input. All three inputs have independent level controls eliminating the need for a separate audio mixer! Just pot-up the source control when ready, and cross fade to the 2nd line input or mic! It's that simple! In addition to the dual stereo line inputs, a stereo monitor output is provided. This is perfect to drive studio monitors or local in-house PA systems.

The FM100B series includes an attractive metal case, whip antenna and built in 110/220VAC power supply. A BNC connector is also provided for an external antenna. Check out our Tru-Match FM antenna kit, for the perfect mate to the FM100B transmitter. We also offer a high power kit as well as an export-only assembled version that provides a variable RF output power up to 1 watt. The 1 watt unit must utilize an external antenna properly matched to the operating frequency to maintain a proper VSWR to protect the transmitter.

(Note: The FM100B and FM100BEX are do-it-yourself learning kits that you assemble. The end user is responsible for complying with all FCC rules & regulations within the US or any regulations of their respective governing body. The FM100BWT is for export use and can only be shipped to locations outside the continental US, valid APO/FPO addresses or valid customs brokers for documented end delivery outside the continental US.)

FM100B	**Super-Pro FM Stereo Radio Station Kit, 0-25mW**	**$269.95**
FM100BEX	**Super-Pro FM Stereo Radio Station Kit, 5uW to 1W**	**$349.95**

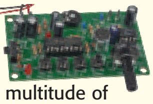
Voice Activated Switch



Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1	**Voice Switch Kit**	**$9.95**

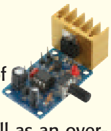
Digital Voice Changer



This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171	**Voice Changer Kit**	**$14.95**

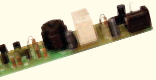
5A PWM Motor Controller



This handy controller uses a pulse width modulated output to control the speed of a motor without sacrificing torque! Handles a continuous current of 5A and includes an LED to indicate speed, as well as an oversized gold heatsink! Also available factory assembled.

CK1102	**5A PWM Motor Controller Kit**	**$14.95**

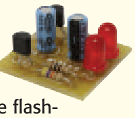
Laser Trip Senser Alarm



True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1	**Laser Trip Sensor Alarm Kit**	**$29.95**

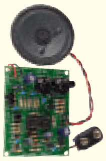
Blinky Kit



The #1 starter kit for Scouts, schools, and hobbyists young and old! Learn the basics, learn soldering, and end up with a neat PC board with two alternate flashing jumbo red LEDs. Great attention getters for signs, hats, pins, and more. Runs on 3-15VDC or battery.

BL1	**LED Blinky Kit**	**$7.95**

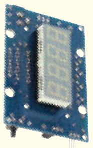
Steam Engine & Whistle



Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

MK134	**Steam Engine & Whistle Kit**	**$11.95**

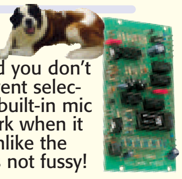
Digital LED Thermometer



This handy thermometer reads Celsius or Fahrenheit on an eye-catching .56" LED display! Based on the DS18B20 sensor and controlled by a PIC, it has a range of -67°F to 257°F (-55°C to 125°C) with a wired remote range of 325 feet!

CK127	**Digital LED Thermometer Kit**	**$29.95**

Electronic Watch Dog



A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike the Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655	**Electronic Watch Dog Kit**	**$39.95**

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SP3B Whether young or old, there's always a need to hone your soldering skills. Either learn from scratch or consider it a refresher, and end up with a neat little project when you're done!

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AMFM108K We not only take you through AM and FM radio theory, but we guide you through IC's. When you're done you've built yourself an IC based AM/FM radio that works great!

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KNS11 Learn alternative fuel technology while you build your own H-Racer car and refueling station!

KNS13 Convert ethanol alcohol to run a PEM fuel cell and watch it all work in front of your eyes!

KNS1 A great beginner's kit for the dinosaur enthusiast in the family, young and old! A wooden hobby kit that teaches motor and gear driven operation that requires no soldering.

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KNS11	**H-Racer & Refueling Station Kit**	**$144.95**
KNS13	**Bio-Energy Fuel Cell Kit**	**$129.95**
KNS1	**Tyrannomech Motorized Kit**	**$17.95**

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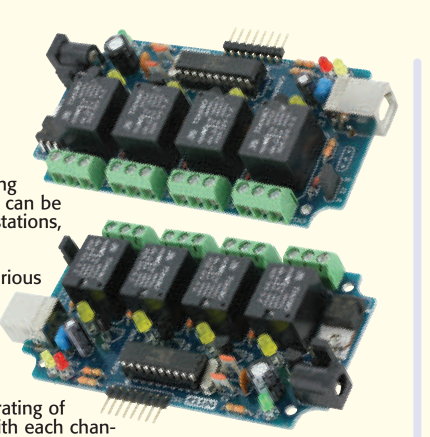


This professional quality USB relay controller and data acquisition module allows computer controlled switching of external devices, plus full bi-directional communication with the external world using the USB port of your computer. The controller is very flexible and can be used for a wide range of custom applications, including weather stations, temperature monitoring, logging and control, etc.

It is compatible with both Windows and Apple OS X, as well as various Linux flavors. When you plug it into your computer, it appears as a USB CDC device that creates a Virtual Serial (COM) port allowing easy communication with the board through any programming language that supports serial communications (VB, VB.NET, C#, C, C++, Perl, Java, etc).

The controller features four onboard relay outputs with a current rating of 10A each. Also onboard is a 6-channel Input/Output interface, with each channel individually configurable as Digital Input, Digital Output, Analog Input (10-bit Resolution), or DS18B20 series Temperature Sensor.

In Digital Input/Output modes, each channel can support a TTL compatible or ST input or a 5V output signal. In Analog Input mode, each channel can convert a voltage of between 0 to 5V into a 10-bit digital representation. Finally, in Temperature Sensor mode, each channel can be connected to a DS18B20 series Digital Temp Sensor.

UK1104 4-Ch USB Relay Interface Kit $59.95

RF Preamplifier

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

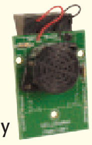
SA7 RF Preamp Kit $19.95

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 Mad Blaster Warble Alarm Kit $9.95

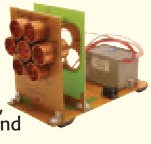
Water Sensor Alarm



This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

MK108 Water Sensor Alarm Kit $6.95

Air Blasting Ion Generator



Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 Ion Generator Kit $64.95

Tri-Field Meter Kit

THE GHOST DETECTOR!

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C Tri-Field Meter Kit $74.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

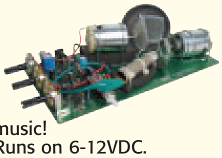
MC1 Mini Electret Condenser Mic Kit $3.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 Touch Switch Kit $9.95

Laser Light Show



Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

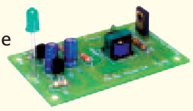
LLS1 Laser Light Show Kit $49.95

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

DDF1 Doppler Direction Finder Kit $169.95

Tickle-Stick Shocker



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 Tickle Stick Kit $9.95

Passive Aircraft Monitor

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

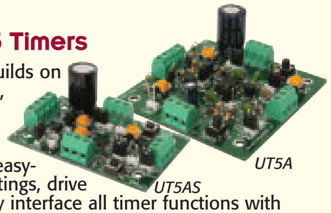
ABM1 Passive Aircraft Receiver Kit $89.95

Sniff-It RF Detector Probe

Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 Sniff-It RF Detector Probe Kit $27.95

Ultimate 555 Timers



This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

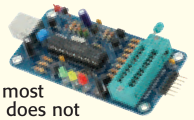
UT5A	**Through Hole 555 Timer/Osc Kit**	**$24.95**
UT5AS	**SMT 555 Timer/Osc Kit**	**$26.95**

Keyless Entry Test Set

Keyless entry systems are great... until they don't work! Now, testing your system is easy. To test the complete key fob-to-vehicle and vehicle-to-key fob communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20kHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. Detects 20kHz, 125kHz, 315MHz, and IR. Requires 9V battery.

WCT3 4-Mode Keyless Entry Test Set Kit $59.00

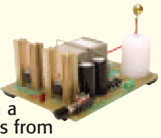
USB PIC Programmer



Finally, a compact USB PIC Programmer with a 20 pin ZIF socket for easy programming of most Microchip PIC Flash devices that does not require low voltage programming. Plus it uses USB, therefore no more RS232 compatibility blues!

CK1301 USB PIC Programmer Kit $34.95

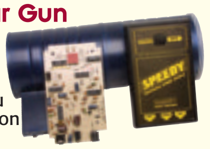
HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

PG13 HV Plasma Generator Kit $64.95

Speedy Speed Radar Gun



Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7 Speed Radar Gun Kit $69.95

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

PR2 Broadband RF Preamp $69.95

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U 3-In1 Multifunction Solder Lab $134.95

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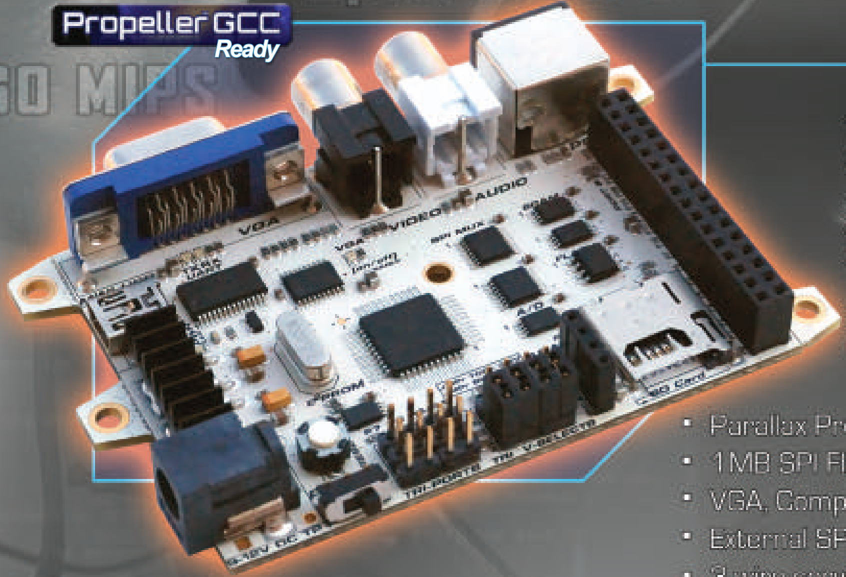
MultiCORE to the MAX!

Synergize with the PropC3 & C3Synapse

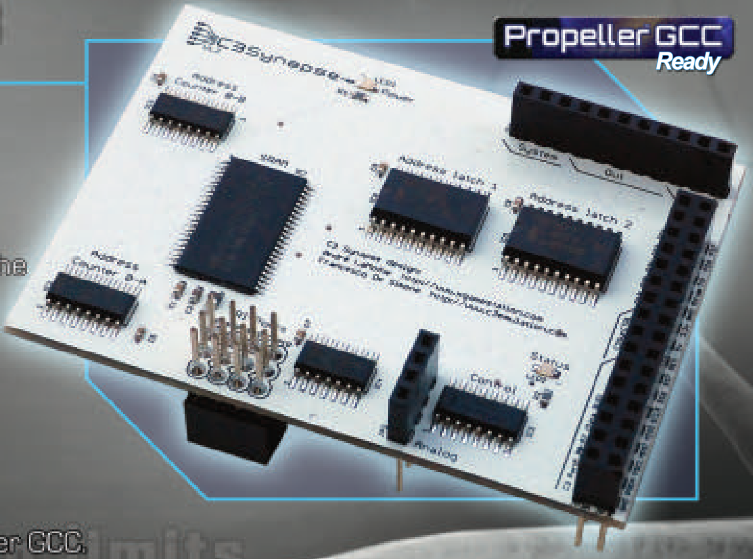


C3

The C3 is a true "Credit-Card-Sized Computer" that augments the Propeller Chip with a generous array of onboard peripherals to facilitate large scale and complex applications. The PropC3 system is ideal for industrial control, remote monitoring, high-level languages, robotics, gaming, and more!

- Parallax Propeller w/ 8 Cores, 32KB RAM, 64KB EEPROM.
- 1MB SPI Flash memory with 64KB of SPI SRAM on board.
- VGA, Composite Video, Audio, PS2 port and Micro SD Card.
- External SPI Bus plus extra I/O lines for interfacing.
- 3 wire servo port headers to drive servos directly.
- 2-channel 12-bit SPI A/D converter.

C3Synapse



The C3Synapse adds 512K bytes of parallel access SRAM to the PropC3 taking the PropC3 to the next level! If you are looking to build more complex applications for the PropC3 then the C3Synapse is the perfect addition to your PropC3 hardware arsenal!

- 512K bytes of ultra fast parallel SRAM.
- Plugs directly into PropC3.
- Drivers, demos, and tutorials included.
- Extra I/O header for additional interfacing.
- Complete "pass thru board" for infinite expansion.
- Programmable in Spin, ASM, and the NEW Propeller GCC.

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